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JASPER L. STUCKEY, STATE GEOLOGIST

ECONOMIC PAPER NO. 65

The Mining Industry in North Carolina From 1937 to 1945

◆◆

BY

THOMAS G. MURDOCK
ASSISTANT STATE GEOLOGIST

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LETTER OF TRANSMITTAL

To His Excellency, HONORABLE W. KERR SCOTT
Governor of North Carolina

SIR:

I have the honor to submit, as Economic Paper 65, a review of the Mining Industry in North Carolina for the years 1937 to 1945 inclusive. In addition to summarizing mineral production figures and important new development in the mining industry for the period covered, the report contains valuable information on the potential mineral resources of the State. There is an increasing interest on the part of mineral producers for information on fuels, metals and industrial minerals and rocks, and it is believed that this report will serve a real need.

Respectfully submitted,

GEORGE R. ROSS
Director

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The Mining Industry in North Carolina From 1937 to 1945

By Thomas G. Murdock
Assistant State Geologist

ABSTRACT

During this period the North Carolina mining industry established an all time record on the basis of value of annual production, attaining a maximum of $22,199,000 in 1944. For the ten-year period of 1936-1945, the annual average value increased 127 per cent over the preceding ten years. The period under review was a most significant one in every respect and particularly in that production of several minerals, notably tungsten, ilmenite, halloysite, and spodumene, was undertaken for the first time. The unprecedented demands for all minerals, occasioned by World War II, brought about important developments in technology and led to detailed geological studies and exploratory work on a scale never before attempted. The salient developments are described in some detail in the present report. Individual sections cover the different minerals, give production statistics, and list the producers. Production statistics cannot be given in the case of commodities which are produced by less than three operators. Producers listed are those making a return in reply to a questionnaire sent out by the United States Bureau of Mines. The distribution of the individual minerals in the State is given; an account of their use is set forth; and a partial bibliography of each mineral is appended. An introductory section discusses the overall achievement of the mining industry during the period, and a brief description of the geology of North Carolina precedes the sections on the different minerals.

INTRODUCTION

North Carolina contains a large potential mineral wealth. More kinds of rocks and minerals are found here than in any other southeastern state and perhaps more than in any other state of the Union. More than 300 varieties of rocks and minerals in the State have been identified and described. More than 70 of these are known to have economic value and between 40 and 50 have been produced in commercial amounts at one time or another during the present century. Although North Carolina does not contain large deposits of mineral fuels and metals, it is an important producer of non-metallics and/or industrial minerals. In the field of non-metallics it is a leading producer of feldspar, primary kaolin, scrap mica and pyrophyllite.

The present report covers the mineral industry for the years of 1937 through 1945, and includes statistical data for 1936 not covered in previous publications. Due to the fact that complete statistics are not available until some time after the end of a calendar year, those for 1945 are the latest which are included; and, in the case of some commodities, the 1945 figures were not available when the chapter covering these was prepared.

ACKNOWLEDGMENTS

The present work was prepared under the helpful supervision of Dr. Jasper L. Stuckey, State Geologist. The statistical tables have been taken from the annual "Minerals Yearbook" of the United States Bureau of Mines. In the preparation of the description of the mineral deposits and mining operations, frequent reference has been made to reports of the United States Geological Survey, the United States Bureau of Mines, the Tennessee Valley Authority, previous publications of the Division of Mineral Resources, and the technical press in general. The writer has been materially assisted in field investigations and in collecting information by Mr. Charles E. Hunter, Geologist, Tennessee Valley Authority, Asheville. Manuscript reports of Dr. William A. White and Dr. E. Willard Berry, of the division staff, have also been sources of information, and the latter has contributed the section of petroleum exploration. To the above-mentioned gentlemen and to the various mineral producers who have kindly furnished information and a ready access to their operations, the writer extends a sincere appreciation.

REVIEW OF THE INDUSTRY

The decade of 1936 to 1945, inclusive, was a most significant one for mining in North Carolina. e most outstanding achievement was the increase in the average annual value of mineral production; r the decade this figure was $17,272,641, as compared with $7,610,583 for the period of 1926-1935—an ncrease of 127 per cent.

The period under consideration was also significant in that the impact of world events was so vivi y reflected in the volume of production. The earlier years saw the recovery from the depths of depressi , with the value of mineral production in the State more than doubled from 1936 to 1940. A slight decre e was noted during 1941 and 1942. Maximum value was reached during 1943 and 1944, with a marked decl e in 1945. The lowest value of production was $9,955,519, in 1936, and the all-time maximum of $22,199,0 was achieved in 1944.

The relation of the value of mineral production of North Carolina to that of the entire country is ins nificant, as the State produces only a fraction of one per cent of the National total. However, expressed n terms of growth, the State total has increased much more rapidly than has the National one. These da are shown in Table 1..

TABLE 1
AVERAGE ANNUAL VALUE OF MINERAL PRODUCTION OF NORTH CAROLINA AND OF THE UNITED STATES BY DECADES 1906–1945

Decade	North Carolina		United States		Per cent of National Total From North Carolina
	Average Annual Value	Growth 1906–15 = 100	Average Annual Value	Growth 1906–15 = 100	
1906–1915	$ 3,150,709	100	$ 2,053,841,000	100	0.15
1916–1925	7,031,071	223	5,140,247,300	250	0.14
1926–1935	7,610,583	242	4,294,000,000	209	0.18
1936–1945	17,272,641	548	6,394,960,000	311	0.27
1906–1945	$ 8,766,251	278	$ 4,470,762,075	213	0.20

That this growth is not related to population is apparent from a study of Table 2. For the decade o 1906-1915, the per capita value of North Carolina's mineral production was $1.43, or only 6.4 per cent o the National average of $22.33. For the 1936--1945 decade, the State average was $4.84, or 10.0 per cent o the $48.57 for the entire country.

TABLE 2
AVERAGE PER CAPITA VALUE OF MINERAL PRODUCTION OF NORTH CAROLINA AND THE UNITED STATES
(Based on 1910, 1920, 1930 and 1940 census figures applied to average for decades.)

Decade	North Carolina		Per Capita Value	United States		Per Capita Value
	Annual Value	Population		Annual Value	Population	
1906–1915	$ 3,150,709	2,206,287	$ 1.43	$ 2,053,841,000	91,972,266	$ 22.33
1916–1925	7,031,071	2,559,123	2.75	5,140,247,300	105,710,620	48.63
1926–1935	7,610,583	3,170,276	4.50	4,294,000,000	122,775,046	34.97
1936–1945	17,272,641	3,571,623	4.84	6,394,960,000	131,669,275	48.57
1906–1945	8,766,251	2,876,827	3.05	4,470,762,075	113,031,800	39.55

In general, the value of production of the individual commodities followed that of the State total, although some items became of a lesser importance as a change from a peace to a war economy was effected. Of the individual products, which can be broken down without revealing confidential information, stone accounted for 27.2 per cent of the State total, and clay products comprised 21.7 per cent. Sand and gravel accounted for 8.0 per cent, followed by mica, crude feldspar, and talc (and pyrophyllite), which made up, respectively, 4.9, 3.3, and 2.5 per cent of the State total. It is significant that the value of the gold and silver production was only 0.5 per cent of that of all minerals. The itemized value of the different minerals produced is shown by years in Table 3.

The most important developments during the decade may be summarized as follows:

(1) Expansion of productive capacity at the bromine plant at Kure Beach near Wilmington, and later the closing down of the plant.

TABLE 3
VALUE OF MINERAL PRODUCTION IN NORTH CAROLINA
From 1936 to 1945, Inclusive

PRODUCTS	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
Clay:										
Products (Other than pottery and refractories)	3,080,434	3,263,898	3,324,461	4,595,857	4,629,000	5,356,000	4,000,000	3,000,000	2,700,000	3,471,219
Raw Sold by producers	126,703	144,639	*	166,010	202,678	*	*	*	423,821	783,220
Feldspar (Crude)	591,052	538,567	295,800	397,631	426,784	552,386	533,448	656,182	788,007	863,740
Gold	71,301	33,203	65,730	17,325	68,005	113,540	142,695	4,585	735	*
Mica:										
Scrap	131,138	209,212	161,598	184,377	173,327	268,596	485,560	516,367	750,285	406,612
Sheet	119,653	218,176	87,879	69,344	218,154	318,783	505,634	1,772,324	1,530,625	243,058
Olivine	----------	----------	----------	15,000	15,000	24,401	45,201	48,633	35,207	*
Grinding Pebbles	----------	----------	----------	----------	----------	102,895	*	*	*	116,300
Sand and Gravel	528,499	539,501	762,827	1,001,369	1,439,457	2,345,165	2,491,820	1,823,516	1,405,917	1,517,203
Silver	4,318	4,284	3,556	2,689	4,608	5,290	5,873	5,098	1,039	----------
Silicia (Quartz)	11,398	6,261	*	*	*	*	*	*	*	*
Stone	3,397,707	3,314,634	5,789,486	6,979,426	4,850,277	4,806,623	3,774,472	5,376,600	5,975,951	2,965,458
Talc and Pyrophyllite	280,026	271,013	241,337	283,789	298,382	567,921	503,082	580,106	645,156	675,789
Titanium Concentrates	----------	----------	----------	----------	----------	----------	*	*	244,980	*
Vermiculite	----------	----------	----------	14,000	8,070	*	19,048	*	*	*
Miscellaneous	1,613,289	4,505,668	4,226,554	4,806,503	8,778,990	4,453,861	4,865,857	8,388,589	7,727,277	3,414,401
Total	9,955,519	13,049,056	14,959,228	18,533,720	21,112,732	18,915,461	17,372,690	22,172,000	22,199,000	14,457,000

* Included under Miscellaneous
Miscellaneous also includes bromine, marble, kyanite, tungsten, lead, manganese, and other items when productions in any year was reported by less than three producers.
Data from United States Bureau of Mines, **Minerals Yearbook** 1936 to 1945.

(2) The application of flotation to the separation of feldspar from associated minerals and the operation of a commercial plant to utilize feldspathic rocks as crude ore for this process.

(3) The re-establishment of mica mining throughout the various districts and the achievement of an all-time high for value of production. Demonstration of the high quality of North Carolina mica.

(4) A determination of the kaolin reserves of the Spruce Pine district, improved technology for kaolin refining, and the establishment of the first plant for local use of kaolin in ceramic manufacturing.

(5) The commercial production of lithium, titanium, and tungsten ores for the first time, and the discovery of sizeable deposits of sillimanite and halloysite.

(6) The utilization of North Carolina granites as grinding media in non-metallic mineral processing.

(7) An intensive investigation of the petroleum possibilities of eastern North Carolina by oil companies and the beginning of exploratory drilling.

(8) A consideration of the possibilities of development of the coal and iron resources of the State and exploration of the deposits.

(9) Comprehensive investigations of the resources of North Carolina by state and federal agencies and the establishment of the Minerals Research Laboratory of North Carolina State College, in Asheville.

The North Carolina Department of Conservation and Development has been active in an inventory of the minerals of the State and since 1940 has completed studies of the manganese, tungsten, chromite, kaolin, mica, feldspar, copper, sillimanite, talc, olivine, and vermiculite deposits. Some of these were independent projects and others were in formal cooperation with the Tennessee Valley Authority and the United States Geological Survey.

The latter agency has also carried out several independent projects, such as tin, tungsten and molybdenum investigations as a part of the Strategic Mineral Investigation being undertaken throughout the United States and some foreign countries.

The United States Bureau of Mines undertook exploration of deposits of coal, iron, copper, tungsten, manganese, molybdenum, barite, corundum, and mica during the war period. A district office of the Mining Branch and a laboratory of the Metallurgical Branch have been established on the campus of North Carolina State College, at Raleigh.

One of the major problems in the development of the mineral resources of North Carolina, for many years, has been the lack of information on the part of the producers, relative to the proper preparation and utilization of the minerals mined. To aid in overcoming this problem, the State of North Carolina has opened, at 180 Coxe Avenue, Asheville, North Carolina, a Minerals Research Laboratory. The Laboratory is operated by the North Carolina State College in cooperation with the Tennessee Valley Authority. There is also close cooperation with the North Carolina Department of Conservation and Development.

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THE GEOLOGY OF NORTH CAROLINA

North Carolina has a total length from east to west of 503 miles and lies across three geological provinces: the Coastal Plain ,the Piedmont Plateau, and the Appalachian Mountains. The rocks and minerals and their geologic relations in each province are distinctive. Stratigraphically, the rock formations range from ancient pre-Cambrian crystallines of the Mountain Province to coastal and estaurine sands and gravels of Quaternary age, constituting the most easterly formations. The structure of the rock units in some parts of the State is simple and in others is very complex.

The Coastal Plain extends from the Atlantic Ocean on the east to the Piedmont Plateau on the west. Its area is about two-fifths of that of the State, exceeding 21,000 square miles and embracing wholly, or in part, 42 of the 100 counties. It is underlain by relatively young, loosely consolidated sediments that dip gently towards the ocean. The most important known mineral resources of the Coastal Plain are cement materials, clay, greensand, phosphate rock, sand and gravel, shell limestone, shell marl, and peat.

The central hill country, known as the Piedmont Plateau, attains a greater width in North Carolina than in the states to the north and is also far more rugged. The western margin of the Plateau has an altitude of 1,200-1,500 feet above sea level. At places precipitous spurs of the Blue Ridge Mountains project eastward and southeastward across the Piedmont section in irregular, straggling ranges. The area of this region is about 22,000 square miles; its altitude descends gradually from 1,500 to about 300 feet, with an average of approximately 1,000 feet.

The Piedmont Plateau is underlain by a wide variety of formations varying from pre-Cambrian through Triassic in age, which contains rocks of metamorphic, igneous and sedimentary origin. Rocks of metamorphic origin cover more than half the area and consist essentially of gneisses, schists, slates, quartzites, and sheared volcanics. An important zone of igneous rocks, composed chiefly of granites and diorites, crosses the central part of the area. Numerous smaller bodies of such rocks are widely scattered throughout the Piedmont. Sedimentary rock of Triassic age are found in two long narrow bands. One of these lies along the Dan River valley of Stokes and Rockingham counties. The other extends from near Oxford, Granville County, in a southwesterly direction through the Deep River basin to the South Carolina line. Important known industrial minerals of the Piedmont Plateau include barite, clay and shale, granite and gneiss, kyanite, kaolin, limestone, marble, mica, monazite, pyrophyllite, quartz, sandstone, sillimanite, slate, soapstone, spodumene, and trap rock.

The Mountain region of North Carolina includes the Blue Ridge, the Great Smoky Mountains, and the country between, which is occupied by numerous irregular ranges, often separated by narrow valleys and deep gorges. The average altitude of this region is about 2,700 feet above sea level but the summits of many ridges exceed 5,000 feet, and a considerable number of peaks tower above 6,000 feet. Over the larger part of this region are to be found the older crystalline rocks, largely gneisses and granites, which are continuous with those of the western part of the Piedmont Plateau and, like these, are considered of pre-Cambrian age. These rocks are often greatly folded and faulted and extreme metamorphism has frequently obscured or completely obliterated all traces of their original character. On the western and eastern borders of this mountain region, approximately along the line of the Blue Ridge and Great Smokies, are two narrow belts of younger rocks consisting of limestones, sandstones, shales, and conglomerates, and their metamorphic equivalents, crystalline limestones, slates, and quartzites.

The different formations of the Mountain region have furnished suitable materials for construction and have been, in some cases, the host rock for economic mineralization, both metallic and non-metallic. However, the pegmatites and peridotites have been the source of the major mineral development.

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METALLIC MINERALS

GOLD AND SILVER

The gold and silver producing areas of North Carolina are commonly listed as follows:

1. The Eastern Carolina Belt: Franklin, Nash, Warren and Halifax counties.

2. The Carolina Slate Belt: Extending from Person County on the north across the intervening counties to Anson and Union counties on the south.

3. The Carolina Igneous Belt: Paralleling the Slate Belt on the west, and varying from 15 to 35 miles in width.

4. The Kings Mountain Belt: Irregular in shape and extending roughly along the west side of the southern half of the Igneous Belt.

5. The South Mountain Belt: About 300 square miles in Burke, McDowell and Rutherford counties.

6. The Western Belt: The area west of the Blue Ridge.

During the period of 1936 to 1944 there was a varying degree of activity in all of these districts; the total gold production amounted to 14,774.82 fine ounces valued at $517,119 and the total silver production to 51,382 fine ounces valued at $36,755, average unit values being $35.00 and $0.715 respectively. The total gold output of North Carolina from 1799 to 1944, inclusive, is recorded as 1,164,588 fine ounces valued at $24,327,843.

The following tabulations show the production by years for the period under consideration, the number of mines in operation, and the itemization as to source:

Production of Gold and Silver in North Carolina, 1936–1944, Inclusive

Year	Mines			Gold		Silver	
	Lode	Placers	Total	Fine Ounces	Value	Fine Ounces	Value
1936	9	9	18	2,037.17	$ 71,301	5,575	$ 4,318
1937	7	5	12	948.65	33,203	5,538	4,284
1938	14	6	20	1,878.00	65,730	5,500	3,556
1939	13	4	17	495.00	17,325	3,961	2,689
1940	9	3	12	1,943.00	68,005	6,480	4,608
1941	5	2	7	3,244.00	113,540	7,439	5,290
1942	1	7	8	4,077.00	142,695	8,259	5,973
1943	3		3	131.00	4,585	7,169	5,098
1944	3		3	21.00	735	1,461	1,039

Mine Production of Gold and Silver in North Carolina, 1936–1944, Inclusive in Fine Ounces

Year	Gold				Silver			
	Placers	Dry and Siliceous Ore	Copper Ore	Total	Placers	Dry and Siliceous Ore	Copper Ore	Total
1936	28	1,894	115	2,037	3	1,168	4,404	5,575
1937	7	832	110	949		254	5,284	5,538
1938	17	1,699	139	1,878a		387	4,907	5,500b‡
1939	7	412	76	495		134	3,827	3,961
1940	7	1,834	102	1,943	1	1,257	5,222	6,480
1941	6	3,141	97	3,244	1	2,394	5,044	7,439
1942	1	3,975	101	4,077		2,505	5,754	8,259
1943			131	131			7,169	7,169
1944			21	21			1,461	1,039

a. Includes 23 ounces from lead-zinc ore.
b.‡Includes 206 ounces from lead-zinc ore.

A summary by years is as follows:

1936.—The Fontana Copper Mine, Swain County, was the largest producer of silver and the second largest producer of gold. The Rudisil Mine, near Charlotte, Mecklenburg County, was the largest producer of gold. Placer gold was produced from mines in Cabarrus, Catawba, Guilford, Iredell, Randolph, Rutherford and Union counties. Lode gold came from mines in Cabarrus, Franklin, Gaston, Mecklenburg, Randolph, Stanly, and Swain counties. Operations at eighteen mines were reported for the year.

1937.—The Fontana Copper Mine, Swain County, was the largest producer of silver, and the second largest producer of gold. The Rudisil Mine, in Mecklenburg County, led in the production of gold. Lode gold was also mined in Cabarrus, Gaston, Halifax, Mecklenburg, and Swain counties. Placer gold came from Burke, Cabarrus, Gaston, Mecklenburg, and Montgomery counties. Twelve mines were in operation during the year.

1938.—The Fontana Copper Mine was the largest producer of silver and the third largest producer of gold. The largest production of gold was from the Capps Mine, Mecklenburg County, while the Redisil was second largest producer. Placer gold was produced in Cabarrus, Guilford, Halifax, Stanly, and Union counties. A total of twenty mines was reported as operating during the year.

1939.—The Fontana Copper Mine, Swain County, led in the production of silver, and was the second largest producer of gold. The Capps Mine, Mecklenburg County, was the major gold producer. Minor amounts of placer gold came from Burke, Guilford, Stanly, and Wilkes counties. Seventeen mines were reported as producers during the year.

1940.—The Candor (Old Howie) Mine, Union County, was the principal producer of gold during 1940. The Fontana Copper Mine continued to produce by-product gold and silver. Placer gold was produced in Burke, Halifax, and Rutherford counties. There were twelve active mines reported in 1940.

1941.—The major gold production was from the Candor Mine, Union County, and production from the Fontana Copper Mine continued. Placer production was reported from Halifax and McDowell counties. Seven active mines were reported during 1941.

1942.—The Candor Mine retained its position as the major producer, while sizeable production continued from the Fontana Copper Mine. Gold mining ceased as of October 15 in compliance with a Gold Mining Limitation Order of the War Production Board. During the year eight mines were reported active.

1943.—The only production of gold and silver in 1943 was obtained from copper ores. The principal producers were the Fontana Mine and Adams Mine, Swain County.

1944.—The only output of gold and silver was that recovered as a by-product of the mining of copper iron and copper ores.

1945.—No production was reported for this year.

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CHROMITE

Chromite is the only commercial ore of chromium and is an important ferro-alloy mineral. Its chemical composition is commonly represented by the formula $FeCr_2O_4$ or FeO,Cr_2O_3 which corresponds to 67.86 per cent chromic oxides (Cr_2O_3)). The principal consumption of chromite is as an alloy and in the manufacture of stainless steels. Its use as a neutral refractory has increased considerably since 1927. Chemical industries use chromite salts in electroplating, dying, tanning, pickling non-ferrous metals and making pigments.

Chromite has been known to occur in peridotites of western North Carolina since 1870 and there has been a small intermittent production for more than fifty years. All the deposits are small and the chromite is rather low grade, (chromic oxide less than 45 per cent and the chromium-iron ratio less than 2.5 to 1). However, there are a few occurrences where the chromite, when concentrated, has a Cr_2O_3 content in excess of 48 per cent. Two deposits which appear suitable for beneficiation are at Day Book, Yancey County, and Democrat, Buncombe County. In addition to the deposits mentioned above, occurrences are known at Webster, Jackson County; Leicester, Buncombe County; Holcombe Branch, Madison County; Price Creek, Yancey County; Addie, Jackson County, and Corundum Hill, Ellijay and Norton, Macon County.

During the 1941 field season, the North Carolina Department of Conservation and Development, in cooperation with the Tennessee Valley Authority, carried out field investigations of the chromite deposits. Results of these investigations have been published as Bulletin 42 of the North Carolina Department of Conservation and Development.

During the period of 1936 to 1945, the chromite activity in North Carolina consisted of the following: Prospecting at Webster, by Gillis and Pawel, as part of the experimental work prior to the incorporation of Olivine Products Corporation; a small production during the summer and fall of 1941, by Southern Minerals Company of Asheville, from a portable hydraulicking plant located at the Democrat deposit, adjacent to Ivy River; and prospecting of a low grade occurrence on the Plyler property northeast of Statesville, said to have been done by Max B. Miller and Company, of New York.

A number of the peridotite masses of the State contain large amounts of olivine. Should large scale olivine mining take place, there should be an increased chromite production as a by-product of such mining.

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COPPER

North Carolina has been an intermittent producer of copper for more than a century. During the last twenty years the most important production has come from the Fontana Mine in Swain County. During World War II there was considerable exploration in the different districts but no important new discoveries or revival of former activity resulted.

The North Carolina deposits appear in three zones which follow the regional trend of the country rocks extending generally in northeast-southwesterly directions. The most important is the Western Zone which persists generally across the western edge of North Carolina and extends into the adjacent states of Tennessee, Georgia, and Virginia. The Central Zone appears in the crystalline rocks of the central Piedmont counties, and the Eastern Zone is in the Carolina slates, extending from the Gold Hill area northeastward into Virginia.

Western Zone.—The western Zone is the most important and the only one from which there has been any important production recently. The best deposits occur as fissure veins in schists and gneisses of the crystalline complex. Some appear associated with basic intrusives. The veins are of a complex hydrothermal origin, although there are areas where mineralized zones appear in the schistose country rock.

The predominant ore mineral is chalcopyrite, although other sulphides such as pyrrhotite, chalcocite, and bornite were common in the secondary ores which have now been largely removed. They also contained minor amounts of cuprite, malachite, azurite, and chrysocolla.

The most important copper mines in the Western Zone are as follows: Ore Knob, Ashe County; Cullowhee, Jackson County; Fontana, Swain County; Adams or Hazel Creek, Swain County; Elk Knob, Ashe County; and Savannah, Jackson County. Other well known occurrences include the Peachbottom Mine of Ashe County; Moody Mine, Jackson County; Kitchens Knob, Clay County; Wilkins Knob, Haywood County; Allison prospect, Jackson County; and the McGuire, Macon County.

During the period 1936 through 1944, the Fontana Mine was the most important producer of copper. The Adams (or Hazel Creek) Mine was active during 1943 and 1944. Other activity included exploration work at Elk Knob during 1940, but no production was reported. During 1943 the U. S. Bureau of Mines conducted extensive exploration work at the Ore Knob Mine. Results of this work are summarized in their Report of Investigation 4341. Various field investigations were also made by the U. S. Geological Survey during the war years.

Central Zone.—In the Central Piedmont area of acid crystalline rocks there is a group of sulphide deposits which were worked first for gold and later for copper in the middle nineteenth century. The ore minerals were predominantly pyrite and chalcopyrite—the former sometimes auriferous. All of these properties have long been abandoned. The better known of them are the North Carolina or Fentress, the Gardner Hill, Hodges, North State, Twin, and Jacks Hill properties of Guilford County; the Ludwick, Boger, Hill, and Pioneer Mills properties of Cabarrus County; and the Ray, Ferris, McGinn, Kerns, Cathey, and McLeary properties of Mecklenburg County.

During World War I the Gardner Hill property in Guilford County was prospected. During World War II there was some activity at the Dixie Queen Mine in Cabarrus County; during 1943 Terry and Knowlton shipped a car of 3 per cent copper ore containing some gold and silver from this property.

Eastern Zone.—The Eastern Zone which lies within the boundaries of the "Carolina Slate Belt" is of importance principally at its extremities. In the north it is known as the Virgilina district. At its southern end is the famous Gold Hill and related Cid districts. Between the two are Chatham County occurrences —minor ones on the basis of past history.

VIRGILINA DISTRICT

The Virgilina district was investigated by the U. S. Bureau of Mines during World War II. Much of the information below was taken from their Report of Investigations 4384.

This district is crossed by the North Carolina-Virginia state line about 40 miles east of Danville. About half of the productive area lies within each State. The North Carolina portion comprises an area about 22 miles long and 18 miles wide lying in Granville and Person counties.

Practically all the developed mines of the North Carolina portion of the district lie on the same strike. secondary axis or zone of mineralization appears about ¾ mile northwest of the main axis and runs paralel with it. The ores of the main axis consists of bornite and chalcopyrite in the usual quartz-epidote-calite gangue. Those of the secondary axis include native copper.

The principal mines in the North Carolina portion of the district are:

(a) Blue Wing, about 1½ miles south of Virgilina, having an estimated reserve of 15,000 tons of blockd ore containing 2 per cent copper, 0.8 ounces silver per ton, and 60 per cent silica.

(b) Holloway, about 1¾ miles southwest of the Blue Wing Mine, along the regional strike. From May 897 to April 1903, more than 400 cars of ore were shipped; the average copper content was probably about 0 per cent.

(c) The Durgy or Person Consolidated is about 1 mile west of the Holloway, and has an estimated reerve of 48,000 tons of blocked ore assaying 2 per cent copper, 0.9 ounce of silver and 70 per cent silica, with n average vein width of 8 feet.

During World War II geophysical prospecting and core drilling were carried out at several mines in the irgilina district by the U. S. Bureau of Mines, as part of their program of exploration of strategic minerals.

GOLD HILL DISTRICT

Four mines, and numerous prospects locally called mines, represent the workings of the Gold Hill minng district. They are well confined to the western edge of the slate formation, and apparently to the imediate vicinity of the Gold Hill fault. The important openings are the Gold Hill Mine, the Union Mine, he Whitney Mine, and the Southern Copper and Gold Mining Company's openings.

The Union Copper Mine, 1 mile south of the village of Gold Hill and located along the Cabarrus-Rowan ounty line, was explored by core drilling by the U. S. Bureau of Mines during 1943. Results of this work re summarized in their Report of Investigations 4364.

CID DISTRICT

Immediately north of the Gold Hill District, in the eastern part of Davidson County, is a mineralized rea known as the Cid Mining District. Here, as at Gold Hill, the principal operations centered around the ining of gold. Three general types of ore deposits occur, but the only one of significance for copper conent is similar to the chalcopyrite-rich ores of Gold Hill. Several mines of this type have had short-lived peration, the more important being the Conrad Hill and the Emmons.

CHATHAM COUNTY AREA

Several small copper prospects are known in the southwestern part of Chatham County and in adjaent Moore, Lee, Randolph and Montgomery counties. All of these are of obscure history and doubtful alue, but they aroused some interest during the period of World War II when governmental subsidy was aid for copper produced from newly developed mines.

During the period under consideration, the only significant activity in the area was at the Bear Creek nd the Millright or Phillips Mine.

The Bear Creek Mine is 3 miles (airline) southwest of Harpers Cross Road, in southwestern Chatham ounty. Some prospecting was effected during 1942 and 1943 by the Bear Creek Copper Mine Company, f Wilmington, and during 1944 seven tons of ore were shipped to the U. S. Metals Refining Company at arteret, New Jersey.

The Millright Mine is about 2½ miles southeast of Harpers Cross Roads, on a branch of Little Indian reek, southwestern Chatham County. This property was operated in 1942 and 1943, and it is reported that 60 tons of ore were shipped. During 1943, 33 tons of ore were shipped to the U. S. Metals Refining Comany. Eleven core-drill holes, totalling 1,695 feet, were put down at this property during 1944 by the lessor, . D. Parker of Samarcand. Nine of the drill holes were scattered rather generally about the exposed minralized zones but failed to prove any appreciable quantity of copper ore. The other two holes were located to the north of old workings 500 and 1,000 feet respectively. One of these last showed appreciable values in gold.

Detailed production figures for North Carolina copper ore cannot be given; the figures as published by the U. S. Bureau of Mines are combined with Tennessee, Pennsylvania, and in some years, Virginia. During the period of 1936 to 1944, inclusive, the total figures were as shown in the accompanying table.

MINE PRODUCTION OF COPPER IN TENNESSEE, PENNSYLVANIA, NORTH CAROLINA AND OTHER EASTERN STATES, 1936 TO 1944, INCLUSIVE.

YEAR	Pounds of Copper	Value	Value Per Pound
1936	22,893,000	$2,106,220	$0.092
1937	24,434,500	2,956,575	0.121
1938	21,079,090	2,065,751	0.098
1939	21,295,000	2,214,680	0.104
1940	25,464,000	2,877,432	0.113
1941	27,131,000	3,201,458	0.118
1942	28,348,000	3,430,108	0.121
1943	27,709,000	3,602,170	0.130
1944	25,720,000	3,472,200	0.134

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IRON

The iron ores of the State include all of the chief iron bearing minerals, such as magnetite (the magnetic oxide of iron), hematite (the red oxide), limonite (the brown oxide), and the bog iron ores. At a few places, siderite or spathic iron ore occurs but no deposits of commercial importance have been found.

The principal magnetic iron ores occur in Granville, Stokes, Surry, Catawba, Lincoln, Ashe, Avery and Mitchell counties. Hematite ores are confined to Ashe and Granville counties. Limonite occurs chiefly in Chatham, Gaston, Madison and Cherokee counties, the latter occurrence being the most important. Bog ores occur mainly in the Coastal Plain area.

During the period of 1936 to 1940 the only production was in 1936, amounting to 57 tons of brown ore from the Maltby Mine in Cherokee County, reported by R. T. Heaton of Andrews.

In 1942, the proposal was made to establish a sponge iron industry in North Carolina. Early in 1943, at the direction of Governor J. M. Broughton, the H. A. Brassert & Company, of New York, began an economic survey of the coal and iron resources of the State to determine the possibilities of their utilization in sponge iron manufacture. Reports summarizing this investigation are on file in the N. C. Department of Conservation and Development.

As recommended by the iron ore report, detailed investigations were made of the more promising areas. These are the Big Ore Bank, Lincoln County; the Cranberry deposits of Avery County; and the deposits of Cherokee County. A general description of these areas and results of the investigation are given below.

Big Ore Bank Area.—This magnetic ore-belt extends northeast from a point about 3 miles northeast of Iron Station in Lincoln County to Anderson's Mountain in Catawba County, a distance of 9 miles. The most promising part of the area investigated is at, and near, the Big Ore Bank, 6½ miles east of Lincolnton. It is about 1 mile long and ¼ mile wide. Just north of the Big Ore Bank is the Brevard Mine. About a mile north of the last workings of the Brevard is the Stonewall Mine, followed by the Morgan, Robinson, Morrison, and Beard mines successively at short intervals.

The magnetic survey disclosed four areas on the Big Ore Bank property in which magnetic anomalies were large enough to indicate the presence of commercial ore bodies.

Diamond drilling was started by the United States Bureau of Mines on November 17, 1943, and was continued until April 12, 1944. Ten holes were drilled, having a total length of 4,494 feet. All holes were inclined at approximately 45° and were drilled across the formation. (See U. S. Bureau of Mines Report of Investigation 4347). As a result of this exploration, it was estimated that 300,000 tons of ore were discovered, containing an average of 28.4 per cent iron, and which would yield 100,000 tons of concentrates.

Cranberry Area.—The Cranberry Mine is in Avery County, about 1½ miles south-southeast of the village of Elk Park, and 2½ miles from the Tennessee state line, in an area of extremely rugged topography.

During the war period, magnetic surveys were made in the Cranberry area, by the United States Geological Survey in the spring of 1943, by H. A. Brassert Company in the autumn of 1943, and by the United States Bureau of Mines during 1944 and later years.

Diamond drilling was started by the Bureau of Mines at Cranberry on November 25, 1943, and up to August 26, 1944, a total of 9,892 feet had been drilled in 12 holes. (See U. S. Bureau of Mines Report of Investigation 4274). These operations were continued at different times into the latter part of 1946. A preliminary estimate, based only on the first twelve holes and what might logically be inferred from other information, indicates that the available ore reserve is at least 1,600,000 tons.

In March, 1944, construction was begun on a pilot plant at Cranberry for the production of high-grade magnetite concentrates for use in the Bureau of Mines' sponge iron pilot plant at Salisbury. The mill was completed in May, 1944, and was operated intermittently until December, 1944.

Grinding to 65-mesh or finer was required to liberate the magnetite and gangue minerals, after which concentrates assaying 70.3 per cent Fe, 0.035 per cent S, 0.002 per cent P, and 1.10 per cent SiO_2 were obtained by passing the ground ore through two Crockett Type-K, wet magnetic separators in series. The recovery of magnetic iron was approximately 94 per cent and that of the total iron was approximately 89 per cent. The ratio of concentration amounted to 2.65 tons of ore assaying 30 per cent total Fe to 1 ton of concentrates.

A flow sheet for a 100-ton mill, estimated to cost $80,344 was suggested. The direct operating cost for such a plant is estimated to be $0.84 per ton of feed, not including mining costs, amortization taxes, interest, insurance, or freight charges. Results of the Bureau of Mines work may be found in their Reports of Investigations 3980 and 4274.

Cherokee County Area.—Most of the brown iron ore deposits of Cherokee County are found on both sides of the Valley River, which flows into the Hiwassee River at Murphy. They extend for a distance of 22 miles from Ranger on the southwest to Andrews on the northeast. A few additional deposits are found in the valley of Peach Tree Creek west and south of Peach Tree, 5 miles east of Murphy.

The only deposits that so far have had commercial importance are those in the Andrews schist near its contact with the overlying Nottely quartzite. This belt extends from the Fain-Hitchcock Mine, a mile southwest of Murphy, northeast for a distance of 15 miles to the Marvacar Mine, south of Andrews and Valleytown.

The tonnage of probable ore below the old workings of the principal mines and most important prospects in the district, has recently been estimated at between 250,000 tons and 500,000 tons.

Following examinations by engineers of the H. A. Brassert Company and the United States Bureau of Mines, exploration was undertaken by the latter agency. The project was begun in April, 1944, and continued intermittently until April, 1945. During this period the following properties were explored by work, as shown in the following tabulation:

PROPERTY	No.	Drill Holes Total Length Feet	No.	Trenches Total Length Feet	No.	Test Pits Total Depth Feet
Cooper Prospect	2	201	13	322	7	32
No. 6 Mine			7	?		
Fain-Hitchcock Mine	1	85	11	334		
Savage Brothers Mine	2	157	8	245		
Heaton and Russel Mine	3	253.3	17	606	3	21
Southern Iron Co. Mine	2	188	?	298.2	14	122.2
Luther Prospect					19	121
Hayes-Hobitzell Mine	2	207	15	626	1	7.5

The Bureau of Mines also performed ore-dressing tests on samples of the Cherokee County ores, at the College Park (Maryland) Station. Results of this work are published as Report of Investigation 3974 of the U. S. Bureau of Mines. The brown ores of Cherokee County constitute a reserve of ore desirable for mixing with the red ores of Alabama and Tennessee and for general blast furnace depression in the stee industry. They are quickly available to meet emergency demands, and the capital investment involved is not large.

Sponge Iron Investigations.—Sponge iron, a porous product resulting from the reduction of an iron oxide at a temperature so low that fusion does not occur, has proved a worthy substitute for scrap iron and has been used successfully in the production of a high-quality steel suitable for the manufacture of too and cutlery instruments. High-grade sponge iron proved unusually effective in producing tool steels in basic electric furnaces. When used with scrap containing contaminating elements such as lead, copper tin, and zinc, the sponge iron improves the quality of the product due to the fact that it contains little or none of them. Because high grade sponge iron imparts desirable qualities to steel, tool manufacturers are interested in its commercial production.

During the wartime shortage of scrap for steel making, the United States Bureau of Mines carried out extensive investigations on the manufacture of sponge iron. This work included North Carolina iron ore as raw materials. In the spring of 1944, tests on Cranberry concentrates were carried out by the Bureau at the plant of the Isenhour Brick and Tile Company, in Salisbury, Rowan County. These tests were highly successful and came up to expectations in every respect.

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LEAD AND ZINC

Lead and zinc are among the most important of the non-ferrous industrial metals and are being consumed on a greatly accelerated scale. The major uses for lead are in storage batteries and cable covering and for zinc in galvanizing and brass making.

Lead is usually found in the form of galena, the sulphide, or associated with zinc blende and pyrite Blende is commonly designated by the mineralogical term "sphalerite." Zinc occurs as calamine and as sphalerite. The former term is used to distinguish the oxidized ores of zinc from the sulphide ores or blendes. The silicate ore is usually designated as smithsonite.

Lead and zinc do not abound in North Carolina; but, when present, they are, as a rule, associated with each other. The lead ores of North Carolina are usually zinciferous, commonly argentiferous, and slightly auriferous.

Geographically, the sulphides of lead and zinc in North Carolina are most prevalent along the western edge of the Carolina Slate Belt and have been found in variable amounts from near the South Carolina line in Union County to the southeast part of Davidson County, near the Randolph County line—a distance of about 50 miles. These minerals are also associated with other sulphides at a number of localities.

The principal localities where the occurrence of lead and zinc is well known are:

Alleghany County: Peachbottom Mine.
Cabarrus County: Rocky River, Allen Furr, McMakin, and Trautman mines.
Caldwell County: Baker Mine.
Davidson County: Silver Hill, Silver Valley, and Welborn (Smith) mines.
Gaston County: Kings Mountain and Lawton mines
Haywood County: Redmon prospect.
McDowell County: In the Shady limestone, a few miles north of Woodlawn.

Montgomery County: Steel, Henderson, and Russell mines.
Randolph County: Hoover and Boss mines.
Rowan County: Union and other mines in the Gold Hill district.
Swain County: Hazel Creek (Adams) Mine.
Union County: Lemmonds, Smart, Stewart, Moore, and Long (or Crowell) mines.
Watauga County: Beech Mountain
Wilkes County: Flint Knob Mine.

During the period under consideration, activity was confined principally to the Silver Hill, Redmon, and Hazel Creek properties. The only record of production was for 1938 when 4 short tons of lead contained in concentrates were shipped. The concentrates were valued at $368.00.

Silver Hill Mine.—This property is situated about 10 miles southeast of Lexington and about 4½ miles northeast of Fairmont, near the source of Buddle Branch. The ore is zinc-lead containing copper, gold and silver. After a long period of idleness the mine was reopened in August, 1938, by T. A. M. Stevenson; one old shaft was cleaned out, and a new prospect shaft was sunk. Only a small quantity of ore was milled; some lead concentrates were shipped to Cartaret, New Jersey, but the zinc concentrates were held for further treatment. The property was reported idle during 1939 and since that date activity has consisted of a small amount of core drilling.

Redmon Prospect.—The Redmon prospect is about 3 miles southwest of Waterville Dam on the Pigeon River in northern Haywood County. It is about 20 miles from the railroad at Junaluska, and about 3 miles by secondary road to the principal highway leading to the railway station.

The ore is of a complex sulphide type and consists of galena, sphalerite, and chalcopyrite. Mineralization is confined to a shear zone of quartz-mica schist lying between an intrusion of Max Patch granite and the Snowbird slate formation.

In the fall of 1939 the Haywood Mining Corporation of Canton opened up an exploratory drift. In May, 1940, these operations had exposed the vein for about 40 feet and a maximum width of 14 feet. The vein can be traced to the north for about 300 feet. It is reported that approximately 60 tons of ore was mined and cobbed down to 45 tons of concentrate for shipment. A small amount of prospecting and core drilling was done in 1941. In the spring of 1943, development was again resumed; in the course of which 24 channel samples were taken from the drift. Of the 24 samples, 3 showed better than 7.2 per cent combined Pb and Zn, while the average was about 2 per cent. Copper content of these samples was generally low.

Hazel Creek (Adams) Mine.—This property, near Procter in Swain County, has been described in a preceding section as a copper mine. Between April and December, 1943, shipments of crude ore averaged 0.25 per cent Pb and 5.0 per cent Zn. During 1944 about 80 tons of 46 per cent zinc concentrates containing some copper were produced in the mill but were re-treated to recover only the copper when the property was being cleaned up for abandonment in the latter part of that year.

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MANGANESE

Manganese is one of the most important of all the strategic minerals. The steel industry requires ore of metallurgical grade for the manufacture of ferromanganese, the alloy used in making steel, which serves as a deoxidizer and purifying agent, and as an alloying element for special purpose steels. The consumption of manganese per short ton of steel manufactured in the United States during 1943 and 1944 averaged 13.3 pounds. Approximately 5 per cent of the total consumption of manganese is for chemical uses. Such uses include in the manufacture of dry batteries, glass, enamel, paint and varnish dryers, pigments, dyes, and fertilizers.

The known deposits of manganese are distributed quite generally throughout North Carolina, being found as far east as Zebulon, Wake County, and as far west as Murphy, Cherokee County. Some of these contain a large tonnage, but of a type which to date has not been amenable to flotation. Sporadic attempts at development have been made during the past fifty years, but the greatest activity appeared during 1917 and 1918. Activities were renewed immediately prior and during World War II.

The principal occurrences of manganese in North Carolina may be enumerated as follows, on the basis of origin:

Secondary Oxides Derived From the Weathering of Primary Deposits of Manganese Silicates, Mainly Spessartite.—These deposits include the wide manganiferous lead of the Kings Mountain area extending somewhat intermittently southwestward with the regional strike from the town of Mountain View, in Cleveland County, North Carolina, into Cherokee County, South Carolina, where it continues as far as Draytonville. A somewhat similar body of manganiferous schist or slate occurs on the south side of Vineyard Mountain in Clay County near Shooting Creek.

There are other deposits of the spessartite type which differ from the Kings Mountain variety in that they do not visibly incorporate any manganiferous phase of a slate or schist. Instead they have been derived from the weathering of hydrothermal veins which seem to have been dominantly composed of quartz and spessartite. Perhaps the most easily recognized of these vein deposits is on the Avon Privette property in Wake County about three miles east of the town of Zebulon. A similar deposit is located in Surry County near the Wilkes County line about 12 miles west of Mt. Airy and 4 miles north of Dobson near State Highway 89 on the property of R. E. Freeman. In Cherokee County, about 1 mile south of Murphy at the headwaters of Martin Creek, is a deposit known as the Eager property; here the manganese occurs in a vein which is dominantly quartz with small amounts of manganese oxides disseminated through it.

Primary Ore Bodies Composed of Manganese Silicates but Occasionally Carrying Manganese Carbonates.—In Alleghany County, about 3 miles north of Sparta, on a small hill locally known as Crouse Knob, there is an occurrence which is somewhat similar to the spessartite deposits of Wake and Surry counties, but in addition, it carries the manganese carbonate, rhodochrosite, and other manganese silicates.

Secondary Oxides Derived From the Weathering of Manganiferous Limestones.—In Transylvania County there are several manganese deposits which appear along the outcrop of a crystalline limestone. Apparently the limestone occurs as lenses in the Brevard schist. The general location of these deposits is about 6 to 10 miles northeast of Brevard and east of the Asheville road, on State Highway 280, near the Buncombe County line. The best known of these is on the R. N. Lebdell property and is directly adjacent to the Highway about 7 miles from Brevard.

In the western part of Madison County, there are several small prospects for manganese, along the contact between the Cambrian limestone formation and the underlying quartzite. They are situated a short distance south of U. S. Highway 70 in the valley of Upper Shut-in Creek, not far from the Tennessee state line.

Fluvial Terrace Deposits of Manganese Oxides.—The only known occurrence of this type is the North Cove deposit, about 12 miles north of Marion, McDowell County, and ½ mile east of Pitts Station of the C. C. & O. Railroad. The ore is essentially a low grade mixture of clay and soft, earthy manganese oxides with occasionally nodules of harder ore. It appears to be a small remnant of a flood plain deposit which has been partially replaced by manganese oxides.

Manganiferous Magnetites.—Certain of the magnetite deposits of Ashe County carry considerable proportions of manganese oxides. The most outstanding of these is on the Ballou property, on Piney Creek about ½ mile upstream from the intersection of the Piney Creek and Lansing roads.

During the earlier part of the period under consideration there was much interest in the possibilities of development of the manganese resources of North Carolina. This was stimulated by the new discoveries at North Cove about 1939, and at Zebulon in 1940. A detailed report covering the deposits in the State was issued in 1944 by the North Carolina Department of Conservation and Development. In addition to prospecting at Zebulon, and some production at North Cove, the Crouse Knob deposit furnished a small supply, and some prospecting was done at the Eager property. The U. S. Bureau of Mines sampled and carried out metallurgical tests on ores from several of the deposits. The Tennessee Valley Authority also ran concentration tests on ore from the North Cove Deposit. The Bureau of Mines executed core drilling at Zebulon which confirmed previous predictions—that the oxides exist only near the surface and at shallow depths the unaltered spessartite prevails.

The finely divided state of the ore from North Cove, and the siliceous nature of that from Zebulon, have suggested the possibility of their utilization in the manufacture of manganese sulphate; and, early in 1942, the American Mineral and Chemical Company, of Raleigh, built a plant in that city and produced a small amount of sulphate. However, the plant never reached the production stage. This deposit was subsequently worked for a short time by mechanical mining in an attempt to recover metallurgical-grade ore.

The utilization of North Carolina ores for sulphate manufacture is a possibility that deserves further consideration.

OPERATORS OF MANGANESE MINES AND PROSPECTS IN NORTH CAROLINA, 1939—1943

COMPANY	ADDRESS	MINE	COUNTY
American Mineral and Chemical Company	Raleigh	North Cove	McDowell
Clough Manganese Company	Washington, D. C.	North Cove	McDowell
		Zebulon	Wake
		Crouse Knob	Alleghaney
Hiwassee Mineral Company	Raleigh	Eager	Cherokee
North Carolina Manganese Corporation	Zebulon	Zebulon	Wake
Weber, Magann and Company	Philadelphia Pa.	North Cove	McDowell

MANGANESE AND MANGANIFEROUS ORES SHIPPED FROM MINES IN NORTH CAROLINA 1939—1943, IN SHORT TONS

YEAR	Ore Containing 35 Per Cent Or More Manganese	Ore Containing 10 to 35 Per Cent Manganese
1939	48	57
1940	------	213
1941	35	174
1942	------	------
1943	140	115

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MOLYBDENUM

Molybdenum is of importance for the manufacture of extra hard high-speed tool steels. Molybdenum steel s much used in airplane and automobile construction. Sheet and wire molybdenum are used in the radio ndustry as a substitute for tungsten. Some molybdenum compounds are used in making dyes and chem-cals.

About 1935 some deposits of molybdenite were discovered about 5 miles east of Hollister, Halifax Coun-y, North Carolina. The deposits have since been prospected by several shallow pits and trenches and by ne shaft 30 feet deep, but as yet there has been no production from them. The molybdenite, associated ith pyrite, chalcopyrite, and sericite, occurs here in quartz veins as much as 11 feet wide. As outcrops nd float of molybdenite-bearing quartz are found in an area at least 2 miles long, the veins probably have wide distribution. One vein has a known length of 200 feet, but because of poor exposures the length of ost of the veins is undetermined.

In the fall of 1943, the prospects were core drilled by the U. S. Bureau of Mines. (U. S. Bureau of ines, Report of Investigation 4156.) Twenty-eight holes, having a total depth of 4,981 feet, were drilled. hese and 950 feet of trenching led to an estimate of 549,300 tons of induced and inferred ore having an verage MoS_2 content of 0.45 per cent. The possibilities were classed as "nearly commercial" and the value ay be increased by the presence of a little rhenium, disclosed in the course of the ore testing.

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NICKEL

Nickel has found an extensive development and use in the manufacture of alloy steels, both as nickel-steel and in combination with chromium or molybdenum. Such steels possess great hardness, strength, toughness and elasticity. They are therefore widely used for structural purposes, armor plate, automobiles, locomotives and other transportation equipment. Stainless and corrosion-resisting steels are of considerable importance in the auto, aviation, and railway industries. Monel metal is an alloy of copper and nickel and is widely used because of its corrosion-resisting properties and because it can be rolled.

Nickel occurs in North Carolina in association with a number of the dunite dikes—in the form of various nickel sillicate minerals. Genthite ($2NiO.2MgO.3SiO_2.6H_2O$) and garnierite (H_2 [Ni, Mg] $SiO_4 + H_2O$) are the most abundant.

The dunite dike at Webster has a crescent shape and extends from the Sylva Golf Course to ¼ mile northeast of Webster, crossing the Tuckasegee River twice. The nickeliferous deposit occupies a zone 2 miles long and 1/10 mile wide, along the inside of the crescent. The richer portions of this deposit are near the old nickel mine south of the Tuckasegee River, and east of Webster along the highway near the eastern contact of the dunite. The Webster dunite deposit is a part of the peridotite ring-dike which is nearly 6 miles in diameter. Nickel is also found at several other localities along this dike.

An average of many analyses of samples of the Webster nickel ore, taken over the large open cuts but near the surface, has been reported by G. A. Pawel as follows: SiO_2, 41.00%; MgO, 28.2%; FeO, 13.9% NiO, 1.50%; Al_2O_3, 1.6%; Cr_2O_3, 1.1%; MnO_2, 0.25%; and H_2O, 10.00%. On a basis of careful geologic investigations of surface outcrops and shallow pitting, it is estimated that there are probably in excess of 2,500,000 tons of 1 per cent ore.

During the period under consideration, experimental work has been carried out on the Webster nickel silicates. Gillis and Pawel, predecessors to Olivine Products Corporation, attempted beneficiating run-of-mine ore by the usual means of mechanical concentration, but with only partial success. The best results were reported as having been obtained by electrostatic means and by a combination of screening and washing wherein some 80 per cent of the original plus 1 per cent nickel material beneficiated to about 30 per cent and the remaining 20 per cent of tails carrying 0.3 to 0.4 per cent of nickel. The plant was closed down early in 1942. Later experimentation by the TVA, at Virginia Polytechnic Institute, indicated that ordinary ore dressing methods of concentration are unsatisfactory; that done at TVA's Wilson Dam has led to the development of a process which is technically sound, although 2 or 3 per cent nickel ore would probably be required to make it economically feasible.

Early in 1942, six diamond drill holes were put down in the northwestern part of the Webster area, to determine whether the magnetic anomalies found in the geophysical survey indicated the existence of underlying chromite bodies. All six holes intersected numerous nickel silicate mineral seams composed of soft material difficult or impossible to core. Much of the core loss was due to these nickel silicate zones. One hole intersected soft nickel silicate at a depth of 117 feet, which indicates the depth to which these secondary nickel minerals have been formed—and one which is greater than that ordinarily attributed to such occurrences. In the upper 75-foot zone of all the holes, nickeliferous seams, identical with those exposed near the Webster plant, occur every few feet.

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TIN

Tin is industrially the most important of the non-ferrous group of strategic metals. Due to its unique ability to form thin, ductile, non-corrosive and closely adhering films on steel and other metals, its anti-friction properties, and its ability to act as a flux in binding one metal to another, it has become most essential to modern industry.

Preceding the entrance of the United States into, and during, World War II, the domestic tin deposits were investigated by the U. S. Geological Survey and the U S. Bureau of Mines. The work of the former agency included an examination of the tin deposits of the Carolinas. The results of this investigation, published as U. S. Geological Survey Bulletin 936-J, are summarized as follows:

> Cassiterite and spodumene, of possible economic importance, occur in a belt 24.5 miles long and 1.8 miles in maximum width, extending southwestward from Lincolnton to Grover, North Carolina. This belt is in the Piedmont province, an upland with an average altitude of 1,000 feet, and is readily accessible by rail and highway. The region is underlain by crystalline limestone, quartzite, schists, gneisses, and granite. The rocks strike northeast and, in most of the belt, dip steeply northwest. Most of them are deeply weathered.
>
> The tin-spodumene belt lies mostly in North Carolina between Lincolnton and the state line. Cassiterite occurs sparsely in hundreds of spodumene-bearing pegmatite bodies, which were emplaced in joints where the rocks are uniformly competent, and parallel to the layering where competent and incompetent rocks are interlayered. Locally, cassiterite is sufficiently abundant in the pegmatite bodies and closely associated greisen (quartz-muscovite rock) to be of possible commercial value. There are at least 91 such deposits of potential tin ore in North Carolina, and one near Gaffney in South Carolina.
>
> The deposits vary widely in thickness along their strike and dip; about 18 are more than a foot wide. The maximum strike length is 275 feet. Little is known about the downward extension of the bodies, but irregular shapes and unpredictable dimensions are to be expected. The tin content of the ore ranges in general from a trace to more than 6 per cent, and the grade in any one deposit is likely to be far from uniform. Records of production from the Ross Mine, near Gaffney, indicate that its ore averaged possibly 2 per cent of tin; this is probably exceptional. Small placer deposits, of which 3 are known, and thin cassiterite-bearing soils of small extent, might yield 150 tons of metallic tin, but these deposits are likewise low in grade.
>
> Because of their small size, low grade, and scattered distribution, the deposits are not being mined at present, and it seems unlikely that any now exposed could be mined profitably unless the price of tin became extremely high.

Investigations of North Carolina tin ore were made by the U. S. Bureau of Mines, during 1939-1940. Ore samples with feldspathic gangue, containing 1.06 per cent tin, were crushed to pass 10 mesh and separated into four sand products in a laboratory hydraulic classifier. The sand products were treated on a laboratory concentrating table, and yielded concentrates that assayed 68.81 per cent tin, or 92.3 per cent of the total tin.

Early in 1941 the Atlas Collapsible Tube Company, of Chicago, began prospecting at the old Faires Mine near the southern limit of the town of Kings Mountain. A 90 foot shaft was sunk and crosscuts were driven to the northwest and southeast, after preliminary exploration by two churn drill holes. The crosscutting encountered four bodies of possible tin-bearing rock, with an aggregate thickness of approximately 12 feet; but the mineralization as shown by sampling was low-grade and confined to a single pegmatite. The work was abandoned without reaching a production stage.

The same is true of the exploration of the Ka-Mi-Tin Concentrating Company, carried out 2 miles southeast of Lincolnton. Several pegmatite bodies, irregular in shape and attitude, were prospected during 1941 and 1942, by power shovel work in the Jake open cut and by underground work at the Condon shaft.

Some work was done in the Beaverdam Creek area of Northwestern Gaston County, by the Aurum Mining Company of Gastonia. During 1944 ten tons of ore yielded 200 pounds of tin concentrates.

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TITANIUM

Although over sixty mineral species contain titanium, the largest concentrations of the element occur as ilmenite and rutile. Ilmenite is at present the most important commercially of the two; rutile is produced in relatively smaller amounts. The former carries 31.6 per cent titanium, while the latter contains 60 per cent.

The most important use of titanium is for making pigments, over 90 per cent of domestic consumption being used for this purpose. Other uses include making alloys, carbide, welding rod coatings, ceramics, as a steel flux or deoxidizer, and as lamp electrode coatings.

Distribution in North Carolina.—Titanium minerals occur in North Carolina as follows: Veins and lenses of granular ilmenite in Caldwell County, placer rutile in Clay County, ilmenite-magnetite lenses in Ashe and Guilford counties, and ilmenite sands in the rivers and sounds of the coastal region.

Caldwell County.—Exceptionally good deposits of ilmenite occur 1 mile north of Finley Post Office. These consist of a number of closely spaced lenses that make up a more or less continuous vein along the strike for a distance of about 1,000 feet. Core drilling has proven the existence of the ore down the dip to a depth of 200 feet, with a maximum thickness of 35 feet. The ilmenite occurs in quartzite and mica schist members of the Carolina gneiss, and the strike and dip of the ore body are parallel to that of the enclosing formations

The ore is mined by open-cut methods, crushed, ground to size by rod mills, and the slimes removed by rake classifiers. Pug mills are used to scrub the ilmenite particles free of clinging impurities such as talc or chlorite. The concentrates from the plant average about 52 per cent TiO_2. Investigations have shown that 70 per cent of the ore is ilmenite analyzing 41.4 per cent TiO_2 with a grain size ranging from 0.3 or 0.4 mm.

Ilmenite production at this property was begun in January, 1942, by the Yadkin Valley Ilmenite Company, subsidiary of the Glidden Company. During 1943 the output was about 40 tons daily. The 1944 production amounted to 14,908 short tons of concentrates which averaged about 49 per cent TiO_2 The production during 1945 was reported at 17,641 short tons, averaging 53 per cent TiO_2.

Clay County.—Rutile occurs associated with a garnetiferous mica schist in Clay County, North Carolina, and adjacent Towns County, Georgia. The part of the schist containing rutile is more prominent between the towns of Young Harris, Georgia, and Elf, North Carolina. The schist apparently is not a continuous body and the rutile content is quite variable throughout its areal extent. No portions of the schist or enclosed pegmatites, have been found sufficiently rich in rutile to be worked as an ore of titanium. There are, however, numerous placer deposits that have been prospected and worked on a small scale. It is reported that, on the average, slightly more than 20 pounds of rutile per cubic yard were found in these openings.

During 1941 some prospecting of the area was undertaken by Southern Minerals Company, of Asheville In early 1945 some investigations were made by the Tennessee Valley Authority. Later the Hitchcock Corporation undertook some prospecting in the area.

Ashe County.—Magnetite-ilmenite deposits occur in a belt extending from Little Helton Creek near the Virginia-North Carolina line, southwestward to Helton Creek near Sturgill, a distance of about 2½ miles One of the most promising and typical of the magnetite-ilmenite deposits occurs on the property of O. M Young, Grassy Creek, This deposit is on Little Helton Creek 0.2 mile downstream from the state line. The ore body consists of overlapping magnetite-ilmenite lenses associated with hornblende gneiss and Cranberry granite. The individual lenses appear to be slightly more than 100 feet long and probably exceed 25 fee in width. They overlap in such a manner as to form an almost continuous ore body for a distance of abou 2,000 feet. Other titaniferous deposits occur on adjoining properties to the southwest. Some of the deposits on the Young property have been partially exposed by prospect pits and others have natural exposures.

Guilford County.—One mile north of Friendship, Guilford County, there are several exposures of titaniferous magnetite and considerable ilmenite float. These deposits appear, from surface indications, to be narrow elongated lenses of nearly pure magnetite-ilmenite ore. These bodies are quite small, and the commercial possibilities of the area have not yet been demonstrated.

Coastal Area.—In the latter part of 1941, interest developed in the ilmenite sands of Albemarle Sound and its tributaries. The ilmenite content is low but there is a wide distribution of the material. On February 26, 1942, E. I. du Pont de Nemours and Company, of Wilmington, Delaware, entered into a contract with the North Carolina Department of Conservation and Development for an investigation of the deposits. The Dupont Company undertook some exploration in the vicinity of Plymouth and Edenton but later abandoned the project.

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TUNGSTEN

Tungsten, the heaviest of the base metals, has the highest melting point and the highest modulus of elasticity of all metals. It is used for high speed tool steel, lamp filaments, non-ferrous alloys, electrical contacts and electrodes, and for various purposes in the chemical industry. Tungsten-metal powder is a product of the metallurgical industry which has increased in importance.

Four minerals may serve as important sources of tungsten; these are huebnerite ($MnWO_4$), wolframite ($[FeMn]WO_4$), scheelite ($CaWO_4$), and ferberite ($FeWO_4$). Of these the wolframite is the most abundant, while scheelite and ferberite are somewhat rare.

Economic Paper No. 4, of the North Carolina Geological Survey, "The Mining Industry of North Carolina during 1900," contains references to the occurrences of tungsten in Vance and Cabarrus counties, but the potential importance of the deposits was not recognized until 1942, when economic deposits of tungsten minerals were found near Townsville in Vance County by Messrs. Joseph and Richard Hamme.

Vance County.—The Hamme Brothers mined in Vance County on a small scale until August, 1943, when their properties were acquired by Haile Mines, Inc. These operations were taken over in June, 1945, by the Tungsten Mining Corporation, a new company formed by Haile Mines, Inc., and the General Electric Company.

The first shipment of concentrate, some 13,000 pounds, was made in July, 1943. The production from August to December, 1943, was reported as 2,797 tons of ore which yielded 60,501 pounds of concentrates averaging 70 per cent Wo$_3$. The average recovery was 22 pounds of concentrate per ton of ore, probably about 55 per cent of the head value. The 1945 production was 219 short tons averaging 37.89 per cent WO_3. The total production from the property as of January 1, 1947, was 39.051 units of WO_3.

Southern Aggregates Corporation, of Raleigh, acquired considerable property in the area and did some mining in the fall of 1943. No concentrates were reported shipped from this operation.

The first detailed geological work in the tungsten district was done by W. A. White, formerly Assistant State Geologist of the North Carolina Department of Conservation and Development, in February and March 1943. This was followed by investigations of the U. S. Geological Survey and core drilling by the U. S Bureau of Mines.

The diamond-drilling program of the U. S. Bureau of Mines consisted of forty-one holes on seventeen veins; the total footage drilled was 7,083.4. Ore reserves in the central part of the district (to a depth of 50 to 360 feet beneath the surface) were estimated by the U. S. Geological Survey in early 1944 to be 130,000 tons of indicated, and 155,000 tons of inferred, ore averaging about 0.9 per cent of WO_3. It is probable that mining and exploratory work at greater depths will increase these reserves. An additional 25,000 tons of ore carrying about 0.5 per cent of WO_3 are inferred to a depth of 100 feet for a group of leaner veins, some of which are outside the central part of the district.

The Hamme Mine was widely developed by the Tungsten Mining Corporation, and a complete concentrating plant, having a daily capacity of 200 tons, was erected. As of July 1, 1946, the company reported a total measured reserve of 158,000 tons averaging 0.84 per cent WO_3 on three of the known veins.

Cabarrus County.—The occurrence of tungsten minerals at the Flowe, Crosby, and Cullen Gold Mines was recorded in Economic Paper 4 of the North Carolina Geological Survey. However, there has been no recorded interest in these properties during recent years.

The Cline Mine, located 5 miles north of Mount Pleasant, 10 miles northeast of Concord, and about ½ mile south of Watts Crossroad, also contains tungsten minerals. It is reportedly owned by A. L. Nash, of Kannapolis, who cleaned out old workings in early 1946. An examination of the property with a mineralite showed traces of scheelite on the dumps and in some of the old workings. Analyses of picked samples of dump ore gave a WO_3 content as high as 3.97 per cent. The ore occurs in a series of quartz lenses, having a width of 1 to 3 feet, and dipping about 75° NE., and striking N30°W. All these lenses have fairly sharp boundaries and in some cases are entirely separated from each other, while at other times they are connected by thin stringers of quartz. They have been traced for 1,000 to 2,000 feet by a series of shafts and test pits.

The property was examined by the U. S. Bureau of Mines as part of that Agency's War Mineral Investigation and a preliminary report was made in early 1944. Some months later the Bureau explored the property by diamond drilling. The results of this work are published in their Reports of Investigations 4203.

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NON-METALLIC MINERALS

ABRASIVE MATERIALS

Natural abrasives are those rocks and minerals used for abrasive purposes in their original form as they come from mine or quarry, except for crushing, beneficiation, sizing or bonding into the form needed by industry. Manufactured or synthetic abrasives are prepared from metals or mineral raw materials.

Modern technology has made it possible to prepare artificial abrasives that are superior to all of the natural ones except the diamond, the hardest of all. Artificial abrasives have a distinct advantage in that they are of a more uniform quality than the natural ones and their production methods have been developed to such a degree that quantity output is now possible. During recent years they have largely replaced natural abrasives.

Natural abrasives found in North Carolina include corundum, emery, garnet, quartz, and materials suitable for use as millstones, grinding pebbles, and liners. Talc, feldspar, and other minerals are used to a limited extent for special purposes.

Corundum.—Corundum, an oxide of aluminum, is with the exception of the diamond, the hardest mineral known. The most important occurrences in North Carolina are in association with peridotite masses. During World War II the U. S. Bureau of Mines carried out a small amount of exploration in Macon County and a more extensive prospecting at the Buck Creek property in Clay County. A summary of this work is contained in their Report of Investigations 4052.

Emery.—Emery is an intimate mixture of granular corundum and magnetite with or without hematite. There was a small production from Macon County, during 1918, on the property of G. B. Nelson, 2 miles west of Prentiss. Emery has also been reported from Guilford and Yancey counties. There has been no production during recent years.

Garnet.—Garnet is found in a number of localities in North Carolina, particularly in Jackson, Macon, Madison, and Clay counties. A deposit of pink garnet at Sugar Loaf Mountain, 2½ miles south of Willetts, Jackson County, has been worked at intervals, and a considerable tonnage was recovered between 1900 and 1926, however, there has been no recent activity there. Sizeable deposits of garnet, of possible commercial importance, are found near the headwaters of Shooting Creek, Clay County, and near the headwaters of Nantahala River, Macon County. The only production of garnet in North Carolina during the period under consideration has been as a byproduct from milling kyanite near Burnsville, Yancey County. Mining operations ceased early in 1944. No individual production statistics can be given during the period of 1936-1943 inclusive.

Millstones.—The term "millstone," which includes the burrstone and chaser stone is somewhat loosely applied to include circular stones used for general grinding purposes. They are made from any hard and suitable rock varying from a sandstone, basalt, granite, to a quartz conglomerate. The production of millstones in North Carolina has been principally from a quartz conglomerate at Parkwood, Moore County, and from a granite near Faith, Rowan County. The 1936-1944 annual average was valued at $9,241. During this period the only North Carolina producer was Gardner Brothers, Route No. 3, Salisbury.

Tube-mill lining and grinding pebbles.—Flint pebbles and liners are important grinding media in cylindrical or conical mills for the grinding of feldspar and other ceramic products where steel abraded from the grinding media would contaminate the finished product. Southern Products and Silica Company, Lilesville, and W. R. Bonsal Company, Hamlet, produced silica (quartz) pebbles for use as grinding media during the war period.

The urgent demands of the trade led to the use of grinding materials other than flint, among which was granite. By the end of 1940 the Harris Granite Company, Salisbury, was producing granite grinding pebbles from a quarry near Dunns Mountain, Rowan County. Later Peeler and McCombs, Faith, began production of grinding pebbles.

The only production statistics for North Carolina which may be revealed are for 1941 when 6,099 short tons of grinding pebbles were produced, valued at $102,895.

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ASBESTOS

The term "asbestos" is a commercial designation applied to fibrous varieties of several minerals. These minerals differ widely in composition, and the fibers are diverse in strength, flexibility, and consequent usefulness.

Asbestos has three forms of occurrence: (1) Cross fibre found in fissures transverse to the wall. It consists usually of chrysolite, crocidolite, amosite and rarely anthophyllite; (2) Slip fiber lying in slipping planes with the fibers parallel to the walls. It may be either chrysotile or amphibole; (3) Mass fiber with the fiber occurring in bundles or groups. This is always anthophyllite.

On the basis of utilization, asbestos can be divided into two types—spinning and non-spinning. The chief use of spinning fiber is for fabrics and packing, the most important being automobile brake-band linings. The principal use of non-spinning fiber is in the building trades. Asbestos paper, asbestos-cement shingle, and millboard call for the longer grades of fiber, while the shorter is used for asbestos cement. An increasing amount of the better grades of non-spinning fiber is used for molded brake linings.

The uses of anthophyllite are limited because of its lack of strength. However, because of its superior resistance to acids, it is well suited for use in chemical laboratories. Stronger grades are used for chemical filters. The principal uses of North Carolina anthophyllites have been as a mineral filler for pipe covering and as a welding-rod coating.

Activities in North Carolina between 1936 and 1944 may be summarized as follows:

1936.—The National Asbestos Company (Newland, N. C.) produced a small tonnage of anthophyllite at Frank, Avery County. It was processed in the Minneapolis mill and sold for home insulation, similar to that of mineral wool.

1937.—The American Asbestos Company (successor to National Asbestos Company) produced a small quantity of anthophyllite at the Frank property.

1939.—A small tonnage of anthophyllite was mined near Green Mountain, Yancey County.

1940.—The Powhatan Mining Company, Woodlawn, Baltimore, Maryland, and Philip S. Hoyt, then of Franklin, North Carolina, mined small tonnages of anthophyllite asbestos from near Green Mountain and other points in the State.

1941.—The production and sales were three times as large as in 1940; in addition to the producers mentioned for 1940, W. T. Hippey, Micaville, North Carolina, also reported operations in Yancey County.

1942.—The sales of amphibole showed a 20 per cent increase over the 1941 figures. W. T. Hippey and the Powhatan Mining Company continued to operate their mines in the Micaville area of Yancey County. The Industrial Minerals Corporation, of Asheville, began production from their Blue Rock Mine, near Newdale, Yancey County, and marketed substantial quantities. This asbestos rock mass is reported as at least 200 feet wide and 400 feet long.

1943.—Sales of North Carolina asbestos showed a considerable increase over the previous year. The Industrial Minerals Corporation continued operation and became the largest producer of amphibole asbestos in the United States, selling substantial quantities, chiefly for welding-rod coatings. W. T. Hippey also produced a considerable tonnage of anthophyllite; a small amount was produced by another producer from shallow pits in the Chatuge Reservoir area at Elf, Clay County, under license agreement with TVA.

1944.—Sales of asbestos in North Carolina declined greatly in 1944. The Powhatan Mining Company procured amphibole fiber from properties at Micaville.

Because of the small number of producers in North Carolina no production figures may be given.

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BARITE

Barite, commonly known as barytes, is a sulphate of barium. It is generally white, opaque to translucent, and possesses a crystalline or granular texture. Among its more important uses are in oil well drilling fluids, chemicals, lithopane, glass, paints, and rubber.

Deposits of barite are known to occur in three localities in North Carolina: (1) Hot Springs, Madison County, (2) Kings Mountain, Gaston County, and (3) Hillsboro, Orange County.

Hot Springs Area.—The barite in this area is found near Stackhouse, in northwestern Madison County. The area extends in a northeast direction from Bluff Post Office on Spring Creek, down Doe Branch and across the French Broad River at Sandy Bottom to approximately 1 mile northeast of Walnut Gap.

Mining in this area was carried on at various times between the latter part of the nineteenth century and 1927; the greater part of the work was between 1904 and 1916. It is estimated that the area has produced a total of approximately 300,000 tons of crude barite. There has been little activity in recent years.

Kings Mountain District.—In the Kings Mountain district barite is associated with the Battleground schist and the Bessemer granite. Mining or prospecting has been carried on at ten or twelve localities. The barite occurs in veins or elongated lenticular masses enclosed in schists, and usually parallel with the planes of schistosity. The workable veins range from 2 to 6 feet in thickness, and in one case a thickness of 12 feet was reported. The deposits in the Kings Mountain district are almost identical in occurrence and structure with those in the Piedmont province of Virginia and those near Kings Creek, South Carolina. There has been no recent production from this area.

Hillsboro Area.—The Hillsboro area begins 3½ miles southeast of Hillsboro and extends a short distance west on the highway leading from Hillsboro to Chapel Hill. The general conditions as to structure and occurrence of the barite are quite similar to those in the Kings Mountain district.

During the period of 1937-1944, the only activity in North Carolina was in the Hot Springs area where the U. S. Bureau of Mines did some core drilling on the Betts property. A small production was reported by G. H. Schwartz from a new locality near Stackhouse

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BROMINE

Bromine, a dark, reddish brown, highly corrosive liquid, does not occur uncombined in nature but is widely distributed in the form of bromides usually accompanying common salt and magnesium chlorides. The principal use of bromine in the United States is in ethylene dibromide which combines with the antiknock agent tetraethyl lead to form lead bromide. Lead in this form is not corrosive to spark points. In addition to the antiknock fluids, bromine is used in making fumigants, dyes, medicinals, and photographic reagents.

The largest producer of bromine from sea water in the United States during this period, was the Ethyl-Dow Chemical Company's plant at Kure Beach, North Carolina. This plant started production in 1934 and capacity was expanded repeatedly, particularly in 1937, so that the latter part of that year bromine was recovered at the rate of 10,000 tons annually. The heavy requirements for antiknock fluids for mechanized warfare led to an unprecedented need for bromine production and the Kure Beach plant was again enlarged during 1943-44, and during the entire war period constituted the major source of bromine production in the United States. Operations were suspended during the latter part of 1945.

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CLAYS AND CLAY PRODUCTS

Brick and Tile Clays.—North Carolina is rich in clays and shales suitable for the manufacture of structural clay products such as face brick, common brick, hollow building tile, roofing and floor tile, and sewer pipe. Sixty-four of the hundred counties have shown a production in the past, and practically every county has clay deposits which will, at least, make common brick. The increasing demands of the trade for a high grade product have led to a wide utilization of the shale resources of the State.

These shales, which belong to three different geological formations, are found in four areas conveniently located to all parts of the State. These known areas are: (1) The pre-Cambrian slate belt of the central part of the State, particularly that portion of it in Davidson, Stanley, Anson and Union counties; (2) The Cambrian shales near Hot Springs, Madison County, and the Brevard schists of Henderson County; (3) The Triassic shales of the Dan River Coal Field in Stokes and Rockingham counties; and (4) The Triassic shales of the Deep River Coal Field in Durham, Chatham, Lee, Moore, and Anson counties.

During the period of 1936 to 1944, inclusive, the average annual value of heavy clay products, exclusive of refractories and pottery, was $3,772,183; the State ranked eighth in this respect and the value of the products was 3.8 per cent of the total value of the entire country. The value of these products constituted 21.4 per cent of the value of the total mineral production of North Carolina. An all-time high in the value of heavy clay products was established in 1941 when the figure exceeded five million dollars.

During the first years of the period under consideration the value of structural brick products showed a constant rise, which was continued through the years of post-depression construction into the period immediately prior to Pearl Harbor when the peak was reached. During 1941 there were 54 plants in operation in 40 counties; in 1944 only 31 in 26 counties were listed.

Since the beginning of the post-war construction program, there has been a serious shortage of structural clay products as well as all building materials, in North Carolina. Consideration has been given to the ocation of additional brick plants throughout the State.

NAME	ADDRESS	COUNTY
Borden Brick and Tile Company	Durham Goldsboro Sanford	Durham Wayne Lee
Bostic Brick Company	Lattimore	Cleveland
Carolina Brick Company	New Bern	Craven
Cherokee Brick Company	Brickhaven	Chatham
Cunningham Brick Company	Thomasville	Davidson
Dowdy and Sons	Roseboro	Sampson
Elizabeth City Brick Company	Elizabeth City	Pasquotank
Grant Brick Company	Weldon	Halifax
Ideal Brick Company	Linden	Cumberland
Isenhour Brick Company	Colon	Lee
Isenhour Brick and Tile Company	Salisbury	Rowan
Kendrick Brick and Tile Company	Mount Holly	Gaston
Moland-Drysdale Corporation	Etowah	Henderson
Moore, Roger	Acme	Columbus
Mount Gilead Brick Company	Mount Gilead	Montgomery
Nash Brick Company	Rocky Mount	Nash
New Bern Builders Supply Company	New Bern	Craven
Patterson Brick Company	Roseboro	Sampson
Pine Hall Brick and Pipe Company	Madison Pine Hall	Rockingham Stokes
Poe Brick Company	Fayetteville	Cumberland
Pomo Terra-Cotta Company	Pomona	Guilford
Rickman Brick Company	Lillington	Harnett
Riverside Brick Company	Smithfield	Johnston
Sanford Brick and Tile Company	Colon	Lee
Sellers Brick Company, Inc.	Greenville	Pitt
Statesville Brick Company	Statesville	Iredell
Taylor Brick Company	Aulander	Bertie
Yadkin Brick Yards	New London	Stanley

*North Carolina Department of Labor: Directory of Manufacturing Firms, North Carolina, 1944

TOTAL VALUE OF STRUCTURAL CLAY PRODUCTS IN THE UNITED STATES AND IN NORTH CAROLINA

From 1936 to 1944, Inclusive

YEAR	Value of Production		North Carolina Per Cent of Total
	United States	North Carolina	
1936	$ 95,136,775	$ 3,080,434	3.2
1937	109,011,641	3,263,898	3.0
1938	88,798,513	3,324,461	3.7
1939	122,528,069	4,595,857	3.8
1940	114,000,000	4,629,000	4.1
1941	135,000,000	5,356,000	4.0
1942	102,740,000	4,000,000	3.9
1943	75,200,000	3,000,000	4.0
1944	65,472,000	2,700,000	4.1

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Kaolin.—North Carolina has for many years been the leading state in the production of primary or residual kaolin. The kaolins of North Carolina are limited in occurrence to the Piedmont Pleateau and Appalachian Mountain areas of the State. Although kaolins are widespread in the Piedmont Plateau, the production from that area has never been important. The known deposits of commercial importance are limited entirely to the mountain area of the State. Commercial production has come chiefly from two districts. One of these includes Jackson, Macon, Swain, and Haywood counties. The other includes Avery, Mitchell, and Yancey counties. In the first of these districts it is evident that the kaolins were derived from pegmatites. The kaolins of the second, or Spruce Pine District, have been derived almost entirely from a pegmatite granite. This material has been denominated "alaskite" by some investigators.

During the period 1935-1945, the Carolina China Clay Company and the Harris Clay Company have been the principal producers. The Carolina China Clay Company is located at Penland, Mitchell County, while the Harris Clay Company operates several plants and mines.

The Lunday Mine and plant of the Harris Clay Company are situated in Yancey County, just across the North Toe River from Kona, Mitchell County. The kaolin deposit was opened up about 1921 and about 50,000 tons of kaolin have been produced.

The Avery County plant of the Harris Clay Company, formerly operated by Kaolin, Inc., is situated on U. S. Highway 19-E, just north of the North Toe River, and about 5 miles northeast of Spruce Pine. Important deposits on Brushy Creek and Gusher Knob furnished crude kaolin for this plant. At the present time these deposits constitute the most important ones in the Spruce Pine district.

The Sparks plant of Harris Clay Company at Minpro utilized kaolin from a nearby pit. This pit was opened about 1938 and was mined very rapidly to a depth of about 40 feet.

One of the most significant developments during recent years has been the detailed geological investigations to determine the reserves of kaolin in the Spruce Pine district. The first of these, made by geologists of the Tennessee Valley Authority, indicated the reserves of crude kaolin in Avery, Mitchell, and Yancey counties, to be 51,000,000 tons. Assuming a recovery of 10 per cent of refined kaolin from these deposits, 5,000,000 tons would be expected. A survey by the United States Geological Survey, made in 1942, when the possibilities of producing aluminum from white clays were being given serious consideration, indicated 3 to 7 million short tons of refined kaolin was available in four groups of deposits in the Spruce Pine district.

North Carolina kaolins have had a wide use for many years in making china, semi-porcelain and porcelain, mosaic and other tile, and in the manufacture of spark plugs and glass melting pots. A new use is its employment as a raw material in making spun glass. Recent improvements in the refining of kaolin assure to the trade ample supplies of blended kaolin of uniform quality which is equal to the best imported material. The wartime investigations indicated that on the basis of quality, size and accessibility three of the groups of deposits in the Spruce Pine district were potential sources of aluminum ore.

Technological and economic studies on the opportunities for producing semi-porcelain dinnerware and other ceramic products in North Carolina, utilizing North Carolina kaolins as a major constituent, were published by the North Carolina Department of Conservation and Development in 1941 and 1944. In the southeast a potential market, valued at between $4,000,000 and $7,000,000 per year, exists for whiteware and hotel china alone. An encouraging development, in this respect, has been the establishment of the plant of Hyalyn Porcelain, Inc., at Hickory, during 1946, for the manufacture of art porcelain ware.

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Halloysite.—Halloysite, a clay-like aluminum silicate resembling a kaolinite, but amorphous and containing a larger but uncertain quantity of water, has long been known to occur in small quantities in North Carolina. It is only recently that any commercial deposits have been recognized. In 1944, J. K. Patton of Celo, Yancey County, opened a mica mine on the farm of J. R. Sluder, near Alexander, in the northwestern part of Buncombe County. The mica workings exposed a small body of white clay which was thought to be halloysite and eventually Mr. Patton established a market and shipped a small amount of the crude clay Operations were later taken over by the Harris Clay Company, and for some months an appreciable quantit of crude halloysite was shipped. After a short period of idleness, operations were continued on a small scal by Keystone Mining Company, of Asheville.

The Sluder farm halloysite deposit is 2½ miles west of Alexander and 1 mile south of the French Broa River. The halloysite occurs as a principal constituent of a pegmatite which has been partly exposed by mic mining and subsequent work on the clay. It is best exposed in an open cut on the crest of the hill. This cu is about 20 feet in diameter and 45 feet deep at the deepest point. Several irregular short crosscuts hav been driven from the bottom on the cut; however, these have not encountered the wall limit of the pegmatite, and they show it to be at least 30 feet wide at this point. Shallow pits along the strike to the north o the cut indicate the probable continuance of the pegmatite in this direction for about 300 feet. The wall of the open cut and crosscuts show several inclusions of mica schist, usually 1 to 3 feet thick.

The clay is exceptionally white in color and contains less visible free silica than is customary for kaolin However, small flakes of mica are to be seen in the halloysite. The exposures indicate that the clay wa formed by the weathering of a rather pure feldspar lens. The bottom workings at a depth of about 4 feet encountered semi-kaolinized feldspar. The harder pieces of feldspar on the dump appear to be albite There is a gradual transition in the bottom from halloysite to semi-kaolinized feldspar.

Since the discovery of the Sluder deposit several operations formerly regarded as producers of kaoli have been found to contain halloysite. The Arrowood property near Democrat, Buncombe County, is one o these; and the Harris Clay Company is reportedly producing halloysite from a property near Spruce Pine Mitchell County.

Pottery.—During the earlier part of the decade there was a steady increase in the development of th pottery industry in North Carolina. Many carloads have been shipped annually to the large cities, especiall New York, Philadelphia, and Washington.

There are many clays in North Carolina suitable for making high grade pottery. These are the fine sediments underlying the river terraces found in many of the broader valleys, the better clays being foun usually near the shore line of the terraces. Such clays are found underlying the terraces along the Catawb River, north of Morganton and Mt. Holly, Burke County; near Blackburn and Catawba, Catawba County the South Fork of Catawba River, just north of Lincolnton, Lincoln County; the Yadkin River near Wilkesboro, Wilkes County; Elkin, Surry County; including the old terraces of the Deep River, near Ulah an Whynot, Randolph County; in Buncombe and Henderson counties along the French Broad River. In th eastern part of the State along the Cape Fear River near Fayetteville, Cumberland County; the Neuse Rive near Goldsboro, Wayne County; and Contentnea River, a tributary of the Neuse, in Wilson County, nea Wilson, are similar deposits of clay.

POTTERY PRODUCERS IN NORTH CAROLINA FROM 1936 TO 1945, INCLUSIVE

NAME OF PRODUCER	ADDRESS	PLANT LOCATION	
		Town	County
Hyalyn Porcelain, Inc.	Hickory	Hickory	Catawba
Brown Brothers Pottery Co.	Brevard Road, Arden	Arden	Buncombe
Pisgah Forest Pottery	Candler	Arden	Buncombe
Omar Khyyam Pottery	Candler	Candler	Buncombe
Reems Creek Pottery Co.	Weaverville	Weaverville	Buncombe
William Penland Pottery	Candler	Candler	Buncombe
Hilton Pottery Co.	Hickory, Route 1	Hickory	Catawba
Log Cabin Pottery	Guilford College	Guilford	Guilford
Jugtown Pottery	Steeds	Backwoods	Moore
North State Pottery Co.,	Sanford	Sanford	Lee
Kennedy Pottery	Wilkesboro	Wilkesboro	Wilkes
A. R. Cole Pottery	Sanford	Sanford	Lee
Coles Pottery	Steeds	Steeds	Lee
Teague Pottery	Robbins	Robbins	Moore
Melvin Owen	Steeds, Route 1	Steeds	Lee
Glenn Art Pottery, Inc.	Siler City	Steeds	Lee

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FELDSPAR

The feldspars are a series of related aluminum silicates containing varying proportions of potash, soda and lime. They comprise three principal types: Potash feldspars, microcline and orthoclase; soda feldspar or albite; and, soda-lime (plagioclase) feldspars. Properties of the feldspars are similar.

Nearly 90 per cent of the feldspar produced in the United States is used as a flux in the production of glass, pottery, enamel and sanitary ware, and tile. It melts without becoming entirely fluid and upon recooling becomes a strong, colorless or only slightly colored glass. In most pottery it is a part of both body and glaze. Feldspar is one of the essential ingredients in opalescent glass. It is used in dentistry for artificial teeth and porcelain inlays. Enamel for bath tubs, wash bowls, and other purposes contains considerable feldspar. It is one of the principal ingredients in electrical insulators. Other uses are for scouring soaps and window cleaning compounds, as binder for abrasive wheels, as a surface for prepared roofing, as a coating for stucco and concrete, as sand-blast for poultry grit, foundry facings, floor covering sandpaper, paint and wood filler, in terra cotta, and as a flue-dust arrester. Economically important feldspar-bearing pegmatites are known in more than twenty counties in the State, but are confined principally to the mountain district. The pegmatite belt is almost 100 miles wide and extends in a northeast-southwest direction paralleling the Blue Ridge Mountains. The main feldspar belt may be divided into three smaller belts as follows: The Cowee-Black Mountain Belt, the Blue Ridge Belt and the Piedmont Belt. The Cowee-Black Mountain Belt which lies to the west of the Blue Ridge Mountains includes part of Macon, Jackson, Transylvania, Haywood, Buncombe, Yancey, Mitchell and Avery counties, has produced the major part of the feldspar mined in this State. The chief producing district, of which Spruce Pine is the center, is confined to the last three named counties.

Extensive developments in feldspar technology have been reported during the period of 1936 to 1945. Exhaustive research was conducted to determine more efficient means of separating feldspar from quartz and other impurities. Ordinary gravity methods of concentration do not separate feldspar from quartz and certain other associated minerals. Froth flotation of feldspar to rid it of closely associated quartz was perfected by the Bureau of Mines.

A direct result of these developments was the erection of a plant at Kona, in the Spruce Pine district, for the recovery by flotation of feldspar contained in a coarse-grained pegmatitic granite which has been termed alaskite. This plant began operation in the latter part of 1945 and has a daily capacity of 750 tons, with facilities for the recovery of by-product quartz and mica. The operation is by the Carolina Mineral Company, a subsidiary of the Consolidated Feldspar Corporation. The alaskite is quarried from a large open cut, immediately adjacent to the plant.

Within the Spruce Pine area, alaskite occurs in three principal areas, referred to as the Spruce Pine, Penland, and Crabtree alaskite bodies. The largest mass, between Spruce Pine and Chalk Mountain, has a width, unbroken by large inclusions, of 4,000 feet and a length of about 2 miles. Alaskite consists essentially of oligoclase, quartz, microcline, and muscovite, in order of abundance. Ferromagnesian minerals are almost absent in most of the rock, but small amounts of garnet and biotite occur at some places, especially near inclusions or contacts with country rock. Unlike pegmatite, in which irregular mineral distribution s the rule, the alaskite has a relatively uniform mineral composition. In addition to a wide areal distribution f alaskite in the Spruce Pine district, a large mass has been discovered in the Reems Creek area of Buncombe County.

Other new developments in North Carolina include the construction of a feldspar grinding plant at Dillsboro, Jackson County, by Interstate Feldspar Company, during 1945.

On July 1, 1941, a cooperative project between the United States Geological Survey and the North Carona Department of Conservation and Development was inaugurated to study in some detail the economic eology of the pegmatites. Although during the war period the principal emphasis was on mica, such inormation on the occurrence of feldspar was obtained as a by-product.

For the 1936-1944 period, the average annual production of crude feldspar amounted to 93,166 long tons nd average annual value was $529,984. During this period the North Carolina production was 30 per ent of the tonnage produced in the United States and 38 per cent of the total value.

During the period, feldspar production was reported by several hundred operators, including those who produced some feldspar as a by-product from the mining of mica. The following tabulation shows the production, value and unit value of the crude feldspar for each year of the period under consideration.

CRUDE FELDSPAR SOLD OR USED BY PRODUCERS IN NORTH CAROLINA 1936–1944, INCLUSIVE

YEAR	Long Tons	Value	Value Per Ton
1936	102,393	$ 591,053	$ 5.77
1937	94,595	538,567	5.69
1938	56,795	295,800	5.21
1939	76,738	397,631	5.18
1940	79,312	426,784	5.38
1941	100,016	552,386	5.52
1942	93,644	533,448	5.70
1943	112,144	656,182	5.85
1944	112,857	778,007	6.33

PRINCIPAL PRODUCERS OF FELDSPAR IN NORTH CAROLINA IN 1944

NAME OF COMPANY OR PRODUCER	ADDRESS
Clinchfield Sand and Feldspar Corporation	Baltimore, Md.
United Feldspar and Minerals Corporation	Spruce Pine, N. C.
Whitehall Company, Inc.	New York, N. Y.
Sam Thompson	Spruce Pine, N. C.
Avery Mining Company	Plumtree, N. C.
Feldspar Producing Company	Erwin, Tenn.
Waits Pitman	Spruce Pine, N. C.
Houston Bros. and Wise	Senia, N. C.
W. W. Johnson	Crossnore, N. C.
T. L. Blalock	Hazelwood, N. C.
The Solvay Process Company	Syracuse, N. Y.
Balsam Mining and Manufacturing Company	Waynesville, N. C.
Carolina Mining Company	Biltmore, N. C.
Philip S. Hoyt	Van Horn, Tex.
Carolina Mineral Company	Erwin, Tenn.
George Mason and R. W. Love	Spruce Pine, N. C.
Burleson and Ledford	Spruce Pine, N. C.
J. S. Sparks	Spruce Pine, N. C.
R. O. Buchanan	Hawk, N. C.
S. E. Buchanan	Estatoe, N. C.
Charles Silver	Spruce Pine, N. C.
Mt. Mitchell Mining Company	Marion, N. C.
Carolina China Clay Company	Penland, N. C.
Marshall Mining and Milling Company	Bakersville, N. C.
Frank B. Fortner	Spruce Pine, N. C.
Young and Thomas	Boonford, N. C.
Blue Ridge Mining Company	Burnsville, N. C.
John C. Woody	Green Mountain, N. C.
Gudger Robinson	Micaville, N. C.
D. O. Blevins	Spruce Pine, N. C.
Clyde Pittman	Elizabethtown, Tenn.
Worley Buchanan	Micaville, N. C.
Watson Boone and Robert Carroll	Windom, N. C.
Charles Gardner	Burnsville, N. C.
Ellacy Corporation	Burnsville, N. C.
M. D. Cox	Newdale, N. C.
J. Ed. Boone	Burnsville, N. C.
Blaine Garland	Toledo, N. C.

For the years 1936 to 1944, inclusive, the average annual tonnage of ground feldspar sold by North Carolina milling operations and the two mills in Tennessee was 87,029 short tons, or 30 per cent of the total for the entire country. The average annual value was $1,088,399 or 32 per cent of the total for the United States. The accompanying tabulation shows the tonnages of ground feldspar sold, and total and average value, by years, in North Carolina and Tennessee.

GROUND FELDSPAR SOLD BY MERCHANT MILLS IN NORTH CAROLINA AND TENNESSEE, 1936 TO 1944

YEAR	Short Tons	Value	Value Per Ton
1936	85,240	$ 1,153,466	$ 13.53
1937	90,696	1,239,149	13.66
1938	61,467	821,686	13.37
1939	75,740	920,556	12.15
1940	78,077	934,702	11.97
1941	95,391	1,179,577	12.35
1942	86,240	1,037,998	12.04
1943	100,157	1,181,600	11.80
1944	110,251	1,326,861	12.03

PRODUCERS OF GROUND FELDSPAR IN NORTH CAROLINA AND TENNESSEE, 1936 TO 1945

COMPANY	LOCATION OF MILL
Carolina Mineral Company	Kona, N. C.
Consolidated Feldspar Corporation	Erwin, Tenn.
Feldspar Milling Company, Inc.	Bowditch, N. C.
North Carolina Feldspar Corporation	Erwin, Tenn.
The Solvay Process Company	Kings Mountain, N. C.
Southern Feldspar, Inc.	Toecane, N. C.
United Feldspar and Minerals Corporation	Minpre, N. C.

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GEMS AND PRECIOUS STONES

North Carolina has produced gems and precious stones in wide variety. Among these are varieties of uartz, opal, beryl, spodumene (hiddenite), garnet (particularly rhodolite), zircon, rutile, cyanite, epidote, ourmaline, and diamonds. Gems have been found widely scattered in the different counties of the Piedmont nd Mountain sections, Alexander, Burke, Cleveland, Iredell, Jackson, Lincoln, Macon, Mitchell, Transylania, Warren, and Yancey counties having all been producers from time to time in the past.

Other gems and precious stones found in North Carolina are staurolite, spinel, peridot, lazulite, and serentine. Most of these minerals are common; and only rare, clear and transparent varieties, free from flaws, re treasured.

There has never been any systematic prospecting or mining for precious stones in the State. Most of he discoveries have been accidental, but some valuable deposits have been found, and for a long time North arolina was a regular producer of gems. No production was reported for the period 1936-1945.

DEALERS IN GEM MATERIAL AND MINERAL SPECIMENS IN NORTH CAROLINA, 1946

Bradley Johnston	45 Austin Street Asheville, N. C.
Fred O. Scroggs	Brasstown, N. C.
Roby Buchanan	Hawk, N. C.
Linton B. Greene	Spruce Pine, N. C.
Dewey Moose	Stony Point, N. C.

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KYANITE

Kyanite, an aluminum silicate, is common in many areas of metamorphic rocks. It is used in the manufacture of glass, porcelain for spark plugs, refractory brick, electrical and chemical porcelain and china ware, enamelware and hotel-ware. Refractories with these minerals as component parts are used in glasshouse refractories; crucible, boiler, brass-melting, electric, and forging furnaces; high-temperature cements; oil and gas fire boxes; combustion tunnels and cement-kiln linings.

The mineral occurs: (1) in gneiss or schist in disseminated crystals. (2) as lenses in pegmatite dikes, (3) irregularly distributed through quartz veins or quartzitic masses, and (4) in residual clay formed by the weathering of kyanite gneiss. The most important kyanite deposits in North Carolina are found in a belt some 6 to 8 miles wide which extends along the line of the Black and Craggy Mountains from the vicinity of Burnsville, Yancey County, to Swannanoa, Buncombe County. Smaller but interesting deposits occur to the north and south of the main area and in widely separated sections of the Piedmont Plateau.

The only appreciable production of kyanite in North Carolina has been from a property 4 miles south of Burnsville, on Little Celo Mountain. The deposit is cigar-shaped, 250 feet wide by 2,000 feet long, and has been developed at one point with a vertical face of over 150 feet exposed. The ore is a kyanite schist, carrying from 10 to 20 per cent of kyanite. The ore as milled in 1937 carried about 15 per cent kyanite, 10 per cent garnet, 30 per cent mica, and some 5 per cent of miscellaneous minerals.

The original development and operation was by Celo Mines, Inc., under the direction of V. L. Mattson In 1937 the plant was treating 175 tons of crude ore daily on three shifts. Celo Mines operated steadily during 1938. In 1939 flotation equipment was installed for better cleaning of the kyanite concentrates Operations were continued during 1940, but were suspended for a period during 1941, reopening late in the year as Mas-Celo Mines, Inc., subsidiary of Munn and Steel, Inc., 130 Lister Avenue, Newark, New Jersey Operations were again suspended in June 1942. However, after financing by the Reconstruction Finance Corporation and reorganization as the Yancey Cyanite Company, mining and milling were resumed in February 1943 on a schedule of 300 tons of kyanite concentrates a month. This Company continued operations for the remainder of the year as the sole domestic producer of glass-grade kyanite but difficulties were experienced in obtaining a low-iron product. Operations were discontinued on January 5, 1944.

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LITHIUM

Lithium and its minerals and compounds have many and varied uses in industry. The more importan are in the glass, ceramic, chemical, air-conditioning, and metallurgical industries and less extensively in th electrical, pharmaceutical, and optical industries. They are also finding increasing uses in the manufac ture of certain types of lubricants.

Lithium is obtained from three minerals, amblygonite (a fluor-phosphate of aluminum and lithium) lepidolite and zinnwaldite (lithia micas), and spodumene (a lithium-aluminum silicate). All these mineral occur in pegmatites. Lepidolite has been found near Inez, Warren County, North Carolina, and three spodu mene minerals have been identified in the State: the hiddenite or emerald-green variety from Alexande County; kunzite, the purplish variety, from near Spruce Pine; and, the white variety, which occurs in a bel extending from Lincoln through Gaston to Cleveland County. The first two are of interest principally a gems; however, the third is recognized as an important industrial mineral.

The Carolina spodumene belt is aprpoximately co-existent with the tin belt, extending southwestwar from Lincolnton to Grover, North Carolina, a distance of 24.5 miles. The spodumene occurs in tabular peg matite bodies, of lenticular horizontal section, and of unknown vertical dimensions.

The U. S. Geological Survey carried out detailed studies of an area southwest of Kings Mountain, and i the Beaverdam Creek area situated east of Cherryville and north of Gastonia, in conjunction with the in vestigation of the tin deposits of the belt. Although these two areas have a combined length of only 6 1/ miles out of a total of 24½ miles for the entire belt, they contain more than 700 pegmatite bodies 1 feet o more thick. The combined estimate of reserves for the two areas is a minimum of nearly 650,000 tons of spodumene in rock that may be mineable to a depth of 100 feet. Assuming an average of 7 per cent LiO_2, the possible recoverable spodumene estimated above would contain about 45,500 tons of lithia, or more than 20,000 tons of metallic lithium.

The pioneer work in the spodumene belt was by the United Feldspar and Minerals Corporation, of Spruce Pine. This company carried out laboratory investigations on the beneficiation of spodumene and has marketed a mixture of feldspar and spodumene under the trade name of "lithospar." Laboratory research on spodumene beneficiation by flotation was also performed by the U. S. Bureau of Mines.

In 1942 the Solvay Process Company, of Syracuse, New York, carried out detailed testing of the North Carolina deposits, and constructed a concentration plant near Kings Creek, south of the city of Kings Mountain. Operation of the plant started on May 17, 1943, and continued until February, 1945.

During the period of 1936-1944, inclusive, the average annual shipments of ores and compounds from mines in the entire country was 4,239 short tons, valued at $169,013. The contribution of the Kings Mountain plant, the major producer in the country during 1944, is reflected in the increase of the National total from 892 tons, valued at $47,088 in 1938, to 13,319 tons, valued at $552,977 in 1944.

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MICA

Chemically, the micas are highly complex silicates of aluminum and one or more bases. The leading mica of commerce is the potash mica, muscovite, or white mica, while the second in importance is the magne-ium mica, phlogopite, or amber mica. Muscovite, is the common variety in North Carolina although some iotite does occur. No phlogopite has been produced in the State.

Uses of Mica.—Mica has a wide variety of industrial uses both in the sheet and ground forms. The prin-ipal uses for sheet mica is in the electrical industry where it is an important item in the construction of many products including commutators, armatures, airplane engine spark plugs, communication instruments, nd as insulators in many electrical appliances such as irons, toasters, water heaters, etc. Sheet mica is also sed in optical instruments, pyrometers, thermal regulators, fuse boxes, for stove windows, and in many ther items.

The coarser or inferior grade of ground mica, prepared dry, is consumed largely in making roofing; the purer or finer grade, prepared wet, is used in making wallpaper, paint, ornamental tile, concrete, and rub-ber goods. Both wet and dry ground mica are employed for molded insulation, surfacing asphalt shin-gles, Christmas tree snow, lubricants, annealing, enameling of pipe lines, plastic specialties, and many other purposes.

Occurrence.—Mica deposits of commercial value in the State are confined to vein-like bodies called peg-matites and large granite-like bodies referred to as alaskites. The pegmatites vary considerably in form, sme being typically lenticular in shape and others more or less persistent in length. In cross section, some of tese lenses are short and bulky, with a length only two or three times their thickness; others are long and tpering. Pegmatites range from a fraction of an inch up to many yards in thickness. Alaskite bodies, pinciple source of scrap mica, occur as large massive formations several hundred feet across.

Mica-Bearing Areas in North Carolina.—The mica producing areas of North Carolina may be grouped in three major fields. Two of these lie close to the Blue Ridge Range, while the third is southeast of the mountains in the foothills and Piedmont area. Of these the so-called Spruce Pine district, comprising parts o Avery, Mitchell, and Yancey counties, is by far the most important producer. Mica of a high quality has ben mined from more than 500 pegmatites in the district, and in 1944 the district furnished 62 per cent of the State's total mica output. The second field, commonly referred to as the Franklin-Sylva district, is 80 mies southwest of the Spruce Pine district. This area covers parts of Macon, Jackson, and Haywood counties, and is the second most important in the history of mica production in the State. The Piedmont field is confined principally to parts of Rutherford, Cleveland, Gaston, and Lincoln counties. There are many scattered occurrences of mica in commercial quantities outside of the areas mentioned above. In 1944 mica production was reported from nineteen counties.

The Sheet Mica Industry.—Throughout the period under review, North Carolina continued to dominate the domestic mica field. During the years prior to the entry of the United States into World War II, there was increased activity in sheet mica mining in North Carolina. World War II brought an unprecedented demand for strategic mica, and the industry in the State was widely expanded to help meet threatened critical shortages.

The Colonial Mica Corporation, an agent of the government's Metals Reserve Company, was formed in May 1942, in order to coordinate efforts to increase domestic production. Late in 1942 the Corporation was authorized by the War Production Board to be the sole purchaser of strategic grades of domestic mica. Price schedules were fixed by the government, and technical assistance and mining equipment made available to producers.

Under this program there was a great expansion of activity in North Carolina. By March 1944, operations in the State included 79 large mines, 391 small mines and prospects producing 100 pounds or less of strategic quality mica per month, and 49 non-producing prospects. During this month, 2,651 persons were employed in the mines and mica houses. With the lifting of government controls in November 1945, sheet mica mining dropped sharply and many of the mines were closed. The extent to which the mica industry was affected by the revocation of controlled prices is indicated by the production record. In contrast to the peak year of 1943, North Carolina's strategic mica output fell 77 per cent in volume and 86 per cent in value in 1945.

Research and Field Investigations.—During the period of 1940-1945, considerable attention was given to geological investigations of the North Carolina mica areas. In 1941 the North Carolina Department of Conservation and Development began cooperation with the U. S. Geological Survey in making surveys of the principal mica areas in the State. Bulletins 43 and 49 of the Department of Conservation and Development summarize the results of this investigation.

Prior to World War II, Bengal ruby mica was generally accepted as the standard in the classification of mica. During the threatened shortages, early in the war, many grades of green, brown, amber, etc., were used satisfactorily. However, as the shortage became less acute, Bengal ruby was again instituted as the standard. On January 1, 1945, the Colonial Mica Corporation restricted the purchase of domestic mica solely to that of ruby quality. The bulk of North Carolina's mica cannot be classed as ruby.

Since block mica of better than heavy-stained quality, free of mineral inclusions, cracks, pinholes, cross grains, reeves, ribs, and relatively free of clay staining had been accepted as strategic mica, this order seriously threatened mica production in the southeast.

The Department of Conservation and Development obtained the cooperation of the U. S. Geological Survey, Tennessee Valley Authority, Colonial Mica Corporation, Georgia School of Technology, and North Carolina State College in carrying out a detailed testing program to determine the relation between color and quality of mica. Some 2,069 batches of mica, totalling 250,000 sheets, were tested by the Bell Telephone Laboratories "Q-Meter," also known as Type 130-A Mica Test Set. The sheets were also tested with spark test equipment. Results of this investigation indicate that there is no relation between color and quality of mica, and that North Carolina mica, in general, is equal, and in some cases superior, to ruby mica. A detailed report of these findings is awaiting publication.

Production of Sheet Mica.—During the period of 1936-1945, the annual production of sheet mica from North Carolina averaged 1,036,098 pounds; the average annual value was $508,363. Of the average annual production, 186,682 pounds was larger than punch and circle. This comprised 18 per cent of the total sheet mica production and its value was 84 per cent of the value of all sheet. The production of all North Carolina sheet for the ten-year period was 58 per cent of the National total; the value comprised 53 per cent of the total for the country.

The production and value of mica produced in North Carolina for the year 1936-1945 are shown in the accompanying table.

Sheet Mica Sold or Used by Producers in North Carolina, 1936–1945*

Year	Uncut Punch and Circle		Uncut Sheet Larger Than Punch and Circle		Total Uncut Sheet Mica	
	Pounds	Value	Pounds	Value	Pounds	Value
1936	575,915	$ 29,105	154,531	$ 90,548	730,446	$ 119,653
1937	795,684	46,688	248,644	171,488	1,044,328	218,176
1938	552,471	35,885	80,175	51,994	632,646	87,879
1939	320,616	18,629	80,554	50,715	401,170	69,344
1940	848,663	78,214	153,983	139,940	1,002,646	218,154
1941	1,440,349	124,355	174,514	194,428	1,614,863	318,783
1942	1,451,340	180,904	203,555	324,730	1,654,895	505,634
1943	1,543,016	159,535	358,104	1,612,789	1,901,120	1,772,324
1944	474,680	69,025	340,194	1,461,600	814,874	1,530,625
1945	491,428	82,292	72,562	160,766	563,990	243,058

*From U. S. Bureau of Mines, **Minerals Yearbook** (Annual), 1936–1945.

An idea of the distribution of the production is to be obtained from another tabulation which gives the production by counties for the year 1944. This table also shows the production of scrap mica.

Production of Mica in North Carolina in 1944 by Counties*

County	Number of Producers	Sheet Mica		Scrap Mica		Total Value
		Pounds	Value	Short Tons	Value	
Ashe	3	1,504	$ 677	9	$ 205	$ 882
Avery	31	106,511	286,939	111	2,533	289,472
Buncombe	3	1,044	7,024	1,997	39,936	46,960
Caldwell	3	1,386	8,927	------------	------------	8,927
Catawba	4	8,231	16,963	15	309	17,273
Cleveland	4	15,567	2,529	------------	------------	2,529
Jackson	19	93,943	187,337	183	3,646	190,983
Macon	21	89,105	235,750	3,697	84,063	319,813
McDowell	3	1,178	7,459	15	270	7,729
Mitchell	52	110,892	280,121	1,470	39,398	319,519
Rockingham	4	11,347	67,956	83	1,905	69,861
Yancey	43	290,296	256,736	4,750	96,300	353,036
Unspecified	21	600	2,346	17,299	479,137	481,483
Other Counties**	10	83,270	169,861	145	2,583	172,444
Totals	221	814,874	$ 1,530,625	29,774	$ 750,285	$ 2,280,910

*Based on reports of producers to the U. S. Bureau of Mines.

**Includes two producers in Gaston, Haywood and Lincoln counties, and one producer in Stokes, Transylvania, Watauga and other counties.

Mica Prices.—Prior to May 24, 1943, sheet mica was purchased according to size. The price in 1939 ranged from 30 cents to $7.93 per pound for the largest sizes. As the war-time requirements for the smaller sizes of strategic mica increased greatly, a new government price schedule was placed into effect on May 24, 1943, by which a fixed price of $5.00 per pound was offered for all sizes from 1½ x 2 inches and up. The price was subsequently raised in 1944 to $6.00 and later to $8.00 per pound.

PRINCIPAL PRODUCERS OF SHEET MICA IN NORTH CAROLINA DURING 1944

COUNTY	OPERATOR	ADDRESS	MINE
Avery	Daniels and Bowman	Elk Park	Byard Benfield
	Guy and Johnson	Spear	Reuben Green
	E. C. Guy	Newland	Charlie's Ridge
	Aldridge and Flint	Crossnore	Lincoln Rock
	Avery Mining Co.	Plumtree	Meadow
	Goe. M. Bowman	Elk Park	Emmons Knob
	Ollis, Mortimer and Bean	Spear	Old Rock
	Frank Phillips	Ingalls	Moulton
	Sam W. Thompson	Spruce Pine	Mill Race
	V. and O. Mining Co.,	Plumtree	Alfred
	J. J. Harrington	Spear	Red
	Keller and Vance	Spear	Birch
	J. N. Taylor	Spear	Madam Bank
Buncombe	John L. Rice	Barnardsville	Corner Rock
Caldwell	Hise and Buchanan	Lenoir	Cling Daniels
Catawba	Herman Sipe	Hickory	Drum
Gaston	Hendericks and Kennedy	Charlotte	Bess
Haywood	T. L. Blalock	Hazelwood	Big Ridge
	Clyde and Chas. Putnam		Putnam
Jackson	Buchanan Mining Co.	Hawk	Buchanan
	H. E. Buchanan	Sylva	Big East Fork Jasper
	M. D. Cowan	Sylva	Frady
	L. H. Goodman	Dillsboro	Engle Cope
	Harris and Lowhead	Sylva	Kolb
	R. H. Mica Corp.	Sylva	Bowers Tilley
	Chas. E. Closeman	Sylva	Stillwell
Macon	J. L. Barnard	Franklin	Turkey Nest
	Beasley Mining Co.	Franklin	Beasley No. 2
	N. E. Mashburn	Franklin	Hall Welch
	Frank Moody	Franklin	Poll Miller
	A. W. Reid	Franklin	Kiser Lile Knob May Mill Knob
	Wyatt, Berry and Phillips	Franklin	Buoy No. 1
	J. W. and H. S. Roper	Franklin	Arrowood
	Roy H. Fouts	Franklin	Chalk Hill
	Domestic Mica Co.	Franklin	Rocky Face
Mitchell	T. P. Dellinger	Spruce Pine	Long Cut
	Jack McKinney	Bakersville	Jake Howell
	United Feldspar and Minerals Corp.	Spruce Pine	Deer Park No. 5
	Victor Mica Co.	Spruce Pine	Sink Hole
	Yancey Mica Company	Spruce Pine	Rock No. 1
	W. C. McKinney	Spruce Pine	Abernathy
	Newland Buchanan	Spruce Pine	Jimmy Cut
	Drake Mining Co.	Spruce Pine	Dake
	Dave and Clete Dellinger	Spear	Little Hawk Ridge
	E. A. Ellis	Spruce Pine	Rube Sparks
Rockingham	H. A. Knight	High Point	Rosa Evans Knight
Yancey	Anglin and Smith	Burnsville	J. W. Autrey
	D. O. Blevins	Spruce Pine	Blevins
	J. B. Carroll	Celo	Corb Robinson
	Colonial Mica Corp.	Asheville	Poll Hill
	W. F. Deneen	Penland	Cattail Creek
	Feldspar Producing Co.	Spruce Pine	Hoot Owl
	Charles Hyatt	Windom	Green Mountain
	Hensley Laurel Mines	Burnsville	Hensley Laurel
	H. J. Nanney	Micaville	Beech
	C. P. Rodgers	Burnsville	Balsam
	Ollis J. Staton	Micaville	Shehan
	The Whitehall Co.	Spruce Pine	S32__Griffith
	Carroll Rodgers	Burnsville	Pressnell
	Gibbs Mica Co.	Micaville	Big Gibbs
	Joe Gouge	Newdale	Barger
	D. O. Blevins	Spruce Pine	Little Zeph
	Ed and Albert Young	Micaville	Harding

MICA FABRICATORS AND MANUFACTURES IN NORTH CAROLINA

COUNTY	COMPANY	ADDRESS	NUMBER OF EMPLOYEES*
Avery	Tar Heel Mica Co.	Plumtree	76–100
Buncombe	Asheville Mica Co.	Biltmore	701–800
Mitchell	Spruce Pine Mica Co.	Spruce Pine	61–75
Mitchell	Carpenter and Phillips	Spruce Pine	....

*From "Directory of Manufacturing Firms in North Carolina," North Carolina Department of Labor, 1944.

Scrap and Ground Mica.—Scrap mica, by which term is usually meant mine scrap, is that part of the mica mined from which no useful sheet mica can be economically obtained. It is distinguished from mica waste, or bench scrap, by its condition, frequently containing adhering pieces of rock and usually is unrifted. Waste mica, or bench scrap, is obtained from the shops where mica forms are cut or stamped from sheet mica. Cleaner than mine scrap, it commands a higher price. At the mine, scrap mica is discarded from use as sheet mica because of gross imperfections, mineral inclusions, fracture and bent laminae. It represents 70 to 80 per cent of the mica produced in many mines and 100 per cent in some mines.

The four sources of scrap mica in North Carolina, exclusive of shop and factory waste, are: (1) inferior by-product mica from sheet mica and feldspar mines; (2) clay-stained mica recovered from soft, weathered pegmatite, which is mined hydraulically, by power shovel, or by pick and shovel methods; (3) mica recovered in the beneficiation of kaolin and hard alaskite; and (4) mica-rich parts, locally called "schist," of quartz-mica veins, particularly on Tempa Mountain near Spruce Pine. A chlorite schist near Spruce Pine has also been mined by the English Mica Company from their famous "Biotite" mine.

Scrap mica and waste mica are manufactured by being ground to a powder. There are two methods, wet and dry grinding. The better grades of muscovite scrap mica are used in wet grinding because it is desirable to produce a clean, white, sparkling product. Wet-ground mica is used as a paint filler, a substitute for aluminum paint, a coating for wall papers and glossed papers, and an ingredient in certain rubber manufacturers, as well as for a number of other purposes.

Dry-ground mica is produced readily and inexpensively and is a low-priced product. Its chief use is as a coating for roofing papers which are impregnated with asphalt because the mica coating prevents the paper from sticking together when rolled.

Ground mica schist is the leading competitor of dry-ground scrap mica; and certain varieties of mica schist, very light in color, are beginning to be used as raw material for the manufacture of wet-ground mica.

The North Carolina Scrap Mica Industry.—North Carolina has long been the leading producer of scrap mica in the United States. During the period of 1936-1945 inclusive, the average annual production was 8,125 tons; and the average annual value was $328,707. The maximum value of annual production was achieved in 1944 and amounted to $750,285. For the above period, North Carolina contributed 57 per cent f the National total and the value constituted 66 per cent of the National value.

The accompanying tabulation gives details of the production for the period under consideration.

SCRAP MICA AND MICA RECOVERED FROM KAOLIN SCHISTS IN NORTH CAROLINA, 1936–1945

YEAR	Short Tons	Value	Unit Value	Per Cent of Tonnage	National Production Value
1936	10,840	$ 131,138	$ 12.10	52	50
1937	12,988	209,212	16.11	52	59
1938	11,959	161,598	13.51	59	63
1939	13,913	184,377	13.25	56	59
1940	11,595	173,327	14.95	52	55
1941	18,234	268,596	14.73	56	61
1942	24,145	485,560	20.11	56	72
1943	25,295	516,367	20.41	55	70
1944	29,774	750,285	25.20	58	69
1945	22,502	406,612	18.07	68	80

The production of mica as a by-product from kaolin refining accounted for 24 per cent of the entire production for the ten-year period; mica and chlorite schists yielded 17 per cent and the other sources 59 pe cent. The details of the production of mica obtained from kaolin and mica schists for the ten-year period ar given in the following table:

MICA RECOVERED FROM REFINING AND FROM MICA SCHIST IN NORTH CAROLINA, 1936–1945

Year	Short Tons	Value	Unit Value
1936	5,265	$ 82,903	$ 15.75
1937	5,115	90,994	17.79
1938	3,971	64,542	16.25
1939	6,684	82,869	12.40
1940	7,114	101,684	14.29
1941	5,537	90,209	16.29
1942	10,897	255,911	23.48
1943	10,226	199,845	19.54
1944	12,882	379,194	29.44
1945	22,502	406,612	18.24

The processing of scrap mica centers around the principal mica producing areas, although some mic moves from the minor to the larger areas. Small amounts come from other states and some imported ma terial is ground in North Carolina. There are eight plants for grinding mica and schist in the Spruce Pin district. Four plants have been active at Franklin. The production of by-product mica from kaolin refinin and of mica schist is confined to the Spruce Pine district. During the period under consideration, Mitche County produced 37 per cent of all scrap produced, followed by Yancey, Macon, and Avery counties whos production was respectively 24, 17 and 8 per cent.

PRINCIPAL PRODUCERS (MINERS) OF SCRAP MICA IN NORTH CAROLINA, 1945

PRODUCER	ADDRESS	MINE	COUNTY
Avery Mining Co.	Plumtree	Meadow	Avery
Bradley Mining Co.	Franklin	Iotla	Macon
United Feldspar and Mineral Co.	Spruce Pine	Deer Park No. 5	Mitchell
Carolina Mining Co.	Asheville	Carolina	Buncombe
Southern Mica Co.	Johnston City (Tenn)	Harris	Yancey
Whitehall Co.	Spruce Pine	McKinney Group	Mitchell
Victor Mica Co.	Spruce Pine	Sink Hole	Mitchell
Feldspar Producing Co.	Erwin (Tenn.)	Gusher Knob	Avery
Asheville Mica Co.	Biltmore	Wray	Yancey
Liner and Duval	Franklin	Iotla	Macon
Vance Burleson Mica Co.	Spruce Pine	Grindstaff	Yancey
Gwynn Graham	Spruce Pine	Jeff Bird	Mitchell
Monaqua Mining Co.	Asheville	Holland	Yancey
Fred Arnold	Franklin	Shepard Knob	Macon

PRINCIPAL PRODUCERS OF MICA FROM KAOLIN, AND MICA SCHIST IN NORTH CAROLINA, 1942–1945

PRODUCER	ADDRESS	MINE	COUNTY
Harris Clay Co.	Spruce Pine	Various	Mitchell Avery Yancey
Carolina China Clay Co.	Penland	Penland	Mitchell
Victor Mica Co.	Spruce Pine	Crabtree	Mitchell
English Mica Co.	Spruce Pine	Biotite	Mitchell
Southern Mica Co.	Johnston City (Tenn.)	?	Yancey

PRINCIPAL OPERATORS OF MICA GRINDING PLANTS IN NORTH CAROLINA, 1946

PRODUCER	ADDRESS	MILL LOCATION	COUNTY
English Mica Co.	Spruce Pine	Spruce Pine	Mitchell
Bradley Mining Co.	Franklin	Iotla	Macon
Franklin Mineral Products	Franklin	Franklin	Macon
D. T. Vance	Plumtree	Plumtree	Avery
Asheville Mica Co.	Biltmore	Biltmore	Buncombe
Southern Mica Co.	Johnston City (Tenn.)	Micaville	Yancey
Newdale Mica Co.	Newdale	Micaville	Yancey
		Spruce Pine	Mitchell
Victor Mica Co.	Spruce Pine	Spruce Pine	Mitchell

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MONAZITE

Monazite is essentially a phosphate of rare earths with thorium present, probably as a silicate. The thoria content ranges from 0 to about 18 per cent in published analyses, and shows, in addition, a variable content of ceria and minor amounts of the compounds of samarium, erbium, and ytterbium. Owing to its content of thorium and sometimes uranium, it is radioactive. Although there are many other thorium bearing minerals, none is plentiful or cheap enough to compete with monazite.

The rare earths of monazite have rather limited and specialized uses. Ceria and other rare earths are used in the manufacture of glass; cerium fluoride and oxide in the cores of searchlight, motion picture, and therapy-lamp carbons; and cerium acetate as a water- and mildew-proofing compound. Thorium has found an application in the manufacture of radio tubes, tungsten-lamp filaments, high-temperature refractories, as a catalyst, and as an alloy. Lanthanum salts have a bactericidal action and are utilized in beauty preparations; erbium salts are astringents and find use in the same field.

In the United States the principal monazite deposits have been found in the Piedmont region of the Carolinas, as placer deposits in many of the small streams lying in a belt about 30 miles wide and 150 miles ong in western North Carolina and South Carolina. This belt extends southwestward from Alexander County, North Carolina, across northwestern South Carolina and into the northeast corner of Georgia.

Monazite occurs principally in the highly pegmatized phases of the gneisses and schists. Concentrations of possible economic importance are limited, however, to placer deposits derived from the weathering of these rocks. The richer placers occur in gravel beds averaging from 1 to 2 feet in thickness, along the streams and lood plains. The principal occurrences of monazite in North Carolina are near Ellenboro, Rutherfordton, and Duncan, in Rutherford County; near Shelby, Casar, and Mooresboro, in Cleveland County; in the Brindletown Creek and Camp Creek areas of Burke County; and along Silver, South Muddy and North Muddy Creeks, and Henry and Jacobs Forks of the Catawba River. Monazite occurs in a number of adja-ent counties, one of the best known of such occurrences is about 4½ miles southwest of Mars Hill, North Carolina.

The Tennessee Valley Authority made field and laboratory investigations of the North Carolina deposits n the summer of 1943 and over twenty localities were examined and samples taken for laboratory tests. amples of monazite-bearing placer gravels from typical deposits were found to carry less than 1 per cent monazite, and the pure mineral to contain slightly less than 7 per cent thoria. The tests indicated that the gravel is readily concentrated to produce fairly pure monazite with a monazite recovery of about 75 per cent. There has been no production of monazite during the period under consideration.

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OLIVINE

Olivine is usually olive green or pale yellow in color, and occurs in small irregularly outlined crystals and more often, in grains, it has the general formula $(Mg,Fe)_2SiO_4$, and the North Carolina variety often contains detectable amounts of nickel and chrome. Typical samples show a magnesia content of 48.07 per cent and a silica content of 40.47 per cent.

Olivine is a common constituent of basic igneous rocks called peridotites. In western North Carolina and adjacent northern Georgia, there are more than 275 peridotite formations, many of which are in advance stages of serpentinization and steatitization. However, there are about twenty-five large forsterite olivine deposits occurring between Watauga County, North Carolina, on the northeast, and White County, Georgia, on the southwest. The localities in which the principal deposits occur center around Frank, Avery County; Toecane, Yancey County; Canton and Democrat, Haywood and Buncombe counties, respectively; Balsam, Addie, and Webster, Jackson County; Ellijay, Macon County; and Buck Creek and Shooting Creek, Clay County. Field investigations during the summer of 1940 by Charles E. Hunter, geologist of the Tennessee Valley Authority, revealed a reserve of 230,000,000 tons of unaltered olivine from twenty readily accessible deposits. This material contained more than 45 per cent magnesia. It was also estimated that one billion tons of partially serpentinized dunite, composed of 50 per cent or more of olivine averaging about 44 per cent magnesia, were available.

Experiments based on the production of magnesium sulphate were carried out by the Olivine Products Corporation at Webster, Jackson County, North Carolina; and during 1941 and 1942, this organization operated a plant at Webster, producing magnesium sulphate (Epsom salts). The process consisted essentially of digesting crushed olivine in sulphuric acid, separating the iron, and crystallizing the magnesium sulphate from solution. The markets for the salts were the local tanneries, rayon, paper, textile and pharmaceutical trades.

The principal uses for North Carolina olivine have been in the refractories field, where it is the chief raw material in the manufacture of forsterite refractories. Other uses include in fertilizer and as a foundry or blast sand. Research on the manufacture of magnesium metal from olivine has been carried out.

Production of olivine for industrial uses in the United States began in North Carolina on a very small scale in 1930 and production figures between 1936 and 1940 have been estimated at an annual average of 3,500 short tons. Since 1941 the United States Bureau of Mines has conducted an annual canvass of individual producers. Production figures for 1941 to 1944 follow:

PRODUCTION OF OLIVINE IN NORTH CAROLINA, 1941–1944

Year	Short Tons	Value	Value Per Ton
1941	4,828	$ 24,401	$ 5.05
1942	5,739	45,201	7.88
1943	5,415	48,633	8.98
1944	3,270	35,207	10.77

During 1944 prices for crude olivine, f. o. b. North Carolina were quoted at $5 to $7 per short ton. Ground olivine, 200-mesh, $17, and 20-mesh to dust, $12 per ton.

PRODUCERS OF OLIVINE IN NORTH CAROLINA, 1942-1945

PRODUCER	POST OFFICE	LOCATION OF QUARRY	COUNTY
Clinchfield Sand and Feldspar Corp.	Baltimore, Md.	Balsam Gap	Jackson
Harbison-Walker Mining Co.	Pittsburgh, Pa.	Addie	Jackson
Olivine Products Corp.	Sylva, N. C.	Webster	Jackson
United Feldspar and Minerals Corp.	Spruce Pine, N. C.	Balsam Gap	Jackson
		Marshall	Madison
		Micaville	Yancey
		Green Mountain	Yancey
D. C. Wysor	Ridgewood, N. J.	Balsam Gap	Jackson

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QUARTZ

Quartz, an oxide of silicon, commercially called silica, is one of the very widely distributed minerals in nature, occurring as a constituent in a large majority of the crystalline rocks and as the chief mineral in all sandstones. In quantity it occurs chiefly as veins, as bodies of sand, sandstone and quartzite, and in pegmatite dikes.

There are large bodies of quartz in various sections of North Carolina. In parts of the Carolina Slate Belt in Moore, Montgomery, and Randolph counties, veins of quartz are plentiful, some of which are large enough to be of economic value. Vein quartz is also known in Anson, Cherokee, and Jackson counties. Quartz, as quartzite, occurs in large bodies in Cherokee County, and at one time it was worked extensively to provide flux for the copper ores at Ducktown, Tennessee. Quartzite also occurs in Burke, McDowell, Stokes, Surry, Cleveland, and Gaston counties. Quartz as sands and gravels occur in the lower Piedmont and Coastal Plain.

During recent years the main production of silica from North Carolina has been as a by-product from the mining of kaolin, feldspar, and mica in the western section and from sand and gravels of Anson County in the eastern Piedmont.

The chief uses of quartz are: in pottery, scouring soaps, paints, wood fillers, sandpaper, filters, tooth powders, as a flux in copper smelting, and in the manufacture of ferrosilicon. Other uses include the manufacture of chemical ware, as filters for acid towers, and in the manufacture of lenses. Massive rose-colored quartz has value as a gem and ornamental stone.

The high purity quartz of North Carolina achieved National fame when some of it from the Chestnut Flats Mine near Spruce Pine was used in making the 200-inch lens for the world's largest telescope at the California Institute of Technology Observatory. During World War II this quartz was utilized in the manufacture of high-quality lenses.

North Carolina sand and sandstone provide another source of commercial silica. Charlotte Chemical Laboratory, Inc., of Charlotte, has been for many years an important producer of this form of crude, crushed, and ground silica.

In 1936 the quartz production of North Carolina was reported at 1,005 short tons valued at $11,398; for 1937 this figure was 792 tons valued at $6,261. No published figures are available for subsequent years.

PRODUCERS OF QUARTZ AND OTHER FORMS OF SILICA IN NORTH CAROLINA DURING 1944

NAME	ADDRESS
Carolina China Clay Co.	Penland
Carolina Mineral Co., Inc.	Kona
Charlotte Chemical Laboratory, Inc.	Charlotte
Southern Products and Silica Co.	Lilesville
United Feldspar and Minerals Corp.	Spruce Pine
Whitehall Company, Inc.	Spruce Pine

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SAND AND GRAVEL

Deposits of sand and gravel occur throughout many parts of the State. In the Mountain and upp Piedmont regions, deposits are largely restricted to flood plains of streams, while in the lower Piedmont a Coastal Plain they occur over wide areas, roughly following old shore lines. In general, most of the high silica materials are confined to the lower Piedmont and Coastal Plain.

The most important deposits cross the State in a northeast-southwest direction and lie east of the fa line. Geologically they form a series of old terraces which are well developed in parts of Anson, Richmon Moore, Harnett, Johnston, Nash, Halifax and Northampton counties. The principal deposits are near t Pee Dee River in Anson County, well distributed over Moore County, along the Cape Fear River near L lington in Harnett County, and in Halifax and Northampton counties along the Roanoke River. Relative large flood plain deposits have been worked near Swannanoa, Buncombe County, and near Old Fort, M Dowell County.

The production of sand and gravel in North Carolina constituted over 16 per cent of the total value mineral production in the State during the period of 1936 to 1944, inclusive. This is a tremendous increa since 1905, when these materials comprised less than one-tenth of one per cent of the total value. The grow of the industry in the State is shown in the following table.

NUMBER AND AVERAGE PRODUCTION OF COMMERCIAL SAND AND GRAVEL PLANTS IN NORTH CAROLINA, 1910–1940*

YEAR	Number of Plants	Average Production
1910	9	1,828 Tons
1920	11	--------
1930	16	50,014
1940	15	89,430

*From U. S. Bureau of Mines Information Circular 7203.

In addition to commercial operations, the State of North Carolina and other Government agencies ha been large producers to supply aggregates for the tremendous road-building and public works progra which have been in progress during recent years. War-time construction in North Carolina was responsib for the greatly increased production during 1941 and 1942 when all-time records were established on t basis of both tonnage and value. During the period 1936 to 1945 the average annual production was 2,81 207 short tons; the average annual value was $1,385,527. The total production and value are given by yea in the following table.

QUALITY AND VALUE OF SAND AND GRAVEL SOLD OR USED BY COMMERCIAL AND NON-COMMERCIAL PRODUCERS IN NORTH CAROLINA, 1936–1945

YEAR	Short Tons	Value	Value Per Ton
1936	1,515,829	$ 528,499	$ 0.35
1937	1,824,082	539,501	0.30
1938	2,505,180	762,827	0.30
1939	2,383,772	1,001,369	0.42
1940	3,213,855	1,439,457	0.45
1941	4,473,297	2,345,165	0.52
1942	4,280,198	2,491,820	0.58
1943	3,046,168	1,823,516	0.60
1944	2,535,601	1,405,917	0.55
1945	2,394,089	1,517,203	0.63

During 1944 the average number of men employed in production of commercial sand and gravel in North arolina was 267. These operations produced 1,453,797 short tons or 57 per cent of the total. For this roduction 554,155 man-hours were worked—an average production of 2.6 tons per man-hour, slightly under ie National average of 3.3.

The sand and gravel marketed in North Carolina consists chiefly of building sand, gravel for railroad illast, engine sand, paving sand, gravel for road making, and a small quantity of molding sand, filter sand, id sand for grinding and polishing.

The production of the principal kinds of sand and gravel in North Carolina is shown, for the period ider consideration, in the following tabulation.

KINDS OF SAND AND GRAVEL SOLD OR USED BY COMMERCIAL AND NON-COMMERCIAL PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Building Sand		Paving Sand		Engine Sand		R. R. Ballast Sand	
	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value
1936	67,735	$ 23,520	*	*	*	*	17,896	$ 9,640
1937	230,295	45,459	1,111,109	$ 218,405	*	*	*	*
1938	79,230	37,080	1,516,501	370,344	*	*	12,097	7,362
1939	139,413	46,274	1,626,753	457,248	28,500	$ 14,100	----------	----------
1940	206,864	72,343	1,993,048	517,210	48,702	23,801	30,132	18,076
1941	479,581	131,254	2,134,369	520,494	51,861	37,437	----------	----------
1942	1,367,899	519,510	1,332,433	355,145	*	*	77,875	22,275
1943	337,449	136,869	1,511,018	511,656	38,760	26,532	88,815	27,067
1944	159,126	65,736	1,444,150	383,711	33,496	19,997	*	*

YEAR	Building Gravel		Paving Gravel		R. R. Ballast Gravel		Other Sand and Gravel	
	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value
1936	*	*	292,413	$ 149,694	$ 17,895	$ 9,639	1,119,890	$ 336,006
1937	*	*	287,586	138,106	*	*	195,092	137,531
1938	*	*	737,480	228,910	10,510	6,301	149,360	112,830
1939	*	*	349,015	299,678	*	*	240,091	184,069
1940	239,680	$ 233,530	632,040	528,638	30,553	18,496	32,836	27,363
1941	485,692	517,068	734,652	687,594	35,219	24,649	551,923	426,669
1942	465,738	530,304	975,641	1,022,462	34,420	27,335	26,192	14,789
1943	177,369	211,538	787,922	802,974	*	*	104,835	106,880
1944	122,978	153,820	493,450	513,446	104,299	133,126	142,102	136,081

*Included under "other sand and gravel." Data concealed to avoid revealing individual company production.

COMMERCIAL PRODUCERS OF SAND AND GRAVEL IN NORTH CAROLINA IN 1944

NAME OF COMPANY OR PRODUCER	ADDRESS	PLANT LOCATION	
		Town	County
W. R. Bonsal Co.	Hamlet	Lilesville	Anson
B. V. Hedrick Gravel and Sand Co.	Lilesville	Lilesville	Anson
Southern Products and Silica Co.	Lilesville	Lilesville	Anson
Grove Stone and Sand Co.	Swannanoa	Swannanoa	Buncombe
Lower Creek Sand Co.	Lenoir	Lenoir	Caldwell
Bryan-Monroe Co.	Raleigh	Lillington	Harnett
		Kinston	Lenoir
		Garysburg	Northampton
		Goldsboro	Wayne
Neuse Sand Co.	Kinston	Kinston	Lenoir
Aberdeen Sand Co., Inc.	Norfolk (Va.)	Aberdeen	Moore
E. L. Robbins	Wilmington	Wilmington	Northampton
Jobe Sand Co.	Forest City	Forest City	Rutherford
Nantahala Talc and Limestone Co.	Andrews	Nantahala	Swain

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SILLIMANITE

Sillimanite is one of the group of aluminum silicates, including kyanite, andalusite, and dumortierite, which has the property of withstanding high temperatures and of changing into mullite, thus making it useful as a refractory.

The mineral has been known in North Carolina since 1873; however, its earlier identification was incidental to the microscopic examination of samples collected for the study of corundum and cassiterite. In 1943 Charles E. Hunter, of TVA, discovered extensive sillimanite outcrops near the town of Valdese and in the South Mountains of Burke County. A preliminary geological investigation, a joint project of the North Carolina Department of Conservation and Development and the Tennessee Valley Authority, revealed that sillimanite deposits occur in shear zones of low angle thrust faults. The deposits form a belt about 10 miles wide and 95 miles long which enters North Carolina from South Carolina, near Cliffside in Rutherford County, and extends northeastward to the Yadkin River near the Yadkin-Surry county line near Elkin. The belt traverses Rutherford, Cleveland, Burke, Caldwell, Alexander, Wilkes, Iredell and Yadkin counties. There are three other areas where the sillimanite concentration is sufficient to constitute a possible ore: in Clay County where the mineral occurs in a graphite-mica schist and extends from Tusquitee to the Georgia state line; in the Asheville area of Buncombe County, particularly at Oteen, Recreation Park, and Skyland, where it is associated with mica schist and quartzite; and, in the Kings Mountain area, extending southwestward for about 50 miles from near Lincolnton through the town of Kings Mountain to the South Carolina line, where the sillimanite is associated with the Battleground schist and tin-bearing pegmatites.

The Cliffside-Elkin belt is the most extensive, and detailed studies have been made of the more promising areas. The largest and best exposures of sillimanite are in the Prospect Ridge area, 6 miles southeast of Morganton, Burke County, particularly in Smith Cliff and other cliffs along the valleys of Laurel Creek and Henry Ford River. Sillimanite appears to constitute 20 to 60 per cent of the rock in a part of the Foxes Orchard area in the northeast part of Alexander County and adjacent Iredell County, an area extending about 2 miles from near New Hope Post Office to south of Rocky Creek. Both the nodular and fibrolite varieties of sillimanite are found in the vicinity of Ellendale school, 6 miles west of Taylorsville, Alexander County. Several concentrations of sillimanite are found in the northern part of Cleveland County, east and northeast of Casar, in an area about 6 miles long and 3 miles wide. In the extreme southern part of Rutherford County, near Cliffside, a belt of sillimanite schist is found; it is about 2 miles long and ½ mile wide.

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STONE

During the period under consideration, stone has continued to be an item of major importance in contributing to the value of mineral production of North Carolina. The value of stone production comprised 38.7 per cent of the value of the State's mineral production in 1938. This figure decreased to 21.7 per cent n 1942 and averaged 28 per cent for the entire period of 1936 to 1944 inclusive. The average annual production was approximately 3,900,000 short tons and average value of this production comprised 38.7 per cent of the value of all minerals produced in 1938. This figure decreased to 21.7 per cent in 1942 and averaged 28 per cent for the entire period of 1936 to 1944 inclusive. The average annual production was $4,918,353; average unit value was $1.25. The value of the State's production was sixth in 1938, in comparison with the other states, and eighteenth in 1942. The State contributed 2.9 per cent of the value of the production of he United States over the entire period.

The stone produced during the period was principally granite, which constituted 67 per cent of the total onnage and 70 per cent of the total value. Limestone production accounted for 4 per cent of the tonnage and 5 per cent of the total value. Marble, trap rock, and sandstone were other items of production.

Of the total stone production, 93 per cent was used for crushed or broken stone. The value of this maerial constituted 86 per cent of the total value.

STONE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Short Tons (Approximate)	Value	Average Value Per Ton	Per Cent of* National Production	Rank* in Nation	Per Cent of State's Entire Mineral Production
1936	2,724,140	$ 3,397,707	$ 1.25	2.4	16	34.1
1937	2,624,770	3,314,634	1.26	2.3	17	25.4
1938	4,552,120	5,789,486	1.27	4.2	6	28.7
1939	6,037,000	6,979,426	1.16	4.4	7	37.7
1940	3,031,300	4,850,277	1.60	3.0	13	23.0
1941	3,820,200	4,806,623	1.26	2.5	16	25.4
1942	3,039,580	3,774,472	1.24	1.8	18	21.7
1943	4,871,260	5,376,600	1.10	2.9	13	24.2
1944	4,659,520	5,975,951	1.28	3.4	10	26.9

*On basis of value.

CONCRETE AND ROAD METAL, AND RAILROAD BALLAST SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Short Tons	Value	Average Value
1936	2,409,720	$ 2,656,783	$ 1.11
1937	2,594,030	2,782,549	1.07
1938	4,502,950	5,271,878	1.17
1939	5,950,360	6,423,901	1.08
1940	2,691,230	4,150,924	1.54
1941	3,697,880	4,156,644	1.13
1942	2,646,600	3,083,050	1.16
1943	4,020,580	4,019,391	1.00
1944	4,491,710	5,349,378	1.19

COMMERCIAL STONE PRODUCERS IN NORTH CAROLINA, 1945

PRODUCER	ADDRESS	TYPE	QUARRY LOCATION	COUNTY
Duke University	Durham	Slate	Hillsboro	Orange
Salisbury Quarrying Co.	Salisbury	Granite*	Granite Quarry	Rowan
Carolina Pink Granite Co.	Salisbury	Granite*	Granite Quarry	Rowan
Harris Granite Co.	Salisbury	Granite**	Granite Quarry	Rowan
N. C. Granite Corp.	Mt. Airy	Granite**	Mt. Airy	Surry
Piedmont Quarries Co.	Winston-Salem	Crushed Granite	Winston-Salem	Forsyth
Piedmont Quarries Co.	Winston-Salem	Crushed Granite	High Point	Guilford
Buchanan Stone Co.	Greensboro	Crushed Granite	Greensboro	Guilford
Woodleaf Stone Co.	Woodleaf	Crushed Granite	Woodleaf	Rowan
Graystone Granite Quarries	Henderson	Crushed Granite	Graystone	Vance
Bryan-Monroe Co., Inc.	Raleigh	Crushed Granite	Rockton	Wake
Bryan-Monroe Co., Inc.	Raleigh	Crushed Granite	Rolesville	Wake
Bryan-Monroe Co., Inc.	Raleigh	Crushed Granite	Simms	Wilson
Columbia Marble Co.	Marble	Marble*	Marble	Cherokee
Superior Stone Co.	Raleigh	Crushed Limestone	Kings Mountain	Cleveland
Superior Stone Co.	Raleigh	Crushed Limestone	Belgrade	Onslow
Fletcher Limestone Co.	Fletcher	Crushed Limestone	Fletcher	Buncombe
Nantahala Talc and Limestone Co.	Andrews	Crushed Limestone	Hewitts	Swain

*Dimension stone only.

**Both dimension and crushed granite.

NON-COMMERCIAL PRODUCERS IN NORTH CAROLINA, 1945

PRODUCER	TYPE	QUARRY LOCATION	COUNTY
State of North Carolina	Crushed Granite	Various Localities	
City of Morganton	Crushed Granite	Morganton	Burke
U. S. Public Roads Administration	Crushed Granite	Various Localities	
State of North Carolina	Crushed Granite	Woodlawn	McDowell

Granite.—Granite and allied rocks have been, for many years, a major mineral asset of North Carolina. The State ranks first in quality and second in quantity only to Georgia in the southeastern states. Quarries have been successfully developed from a location in the Coastal Plain near Wilson throughout the Piedmont Plateau and into the Appalachian Mountain region as far west as Hendersonville. "Balfour Pink" from Rowan County and "Mount Airy granite" from Surry County are names that have already become well established in the trade and are accepted as a guarantee of high-grade monumental and building stone.

The workable granites of the Coastal Plain region are exposed in Anson and Richmond counties along the South Carolina line, and in Wilson, Edgecombe, and Nash counties to the east of Raleigh. The granites are essentially biotite granites and they show a considerable range in variation of color and texture, from light gray to pink with a very pleasing mixed yellowish and pink appearance in places.

Within the northeastern Carolina Granite Belt, comprising Wake, Franklin, Warren, Vance, and Granville counties, extensive workable areas of different grades of granite are found suited for all grades of work in which granite is used, except for the better grades of monumental rock. Although production has been reported from numerous localities in this belt the principal quarries are at Rolesville and Wendell in Wake County and at Graystone in Vance County.

The Carolina Igneous Belt comprises the main granite belt of the State. Extensive areas of granite are exposed more or less in each of the ten counties included within the belt and, in each county some stone has been quarried from time to time, usually to satisfy local demands. The principal development is to the east and south of Salisbury where the earliest quarrying was many years before the Civil War. The Balfour stone is produced in the Salisbury area. Important quarries for the production of crushed stone have been operated in the Greensboro, Burlington, Charlotte, Winston-Salem, Reidsville, and Salisbury areas.

Massive granites are less abundantly distributed over the western Piedmont gneiss and granite belt than in some other parts of the State. The principal development within the belt has been in Surry, Wilkes, Alleghany, and Alexander counties. The granites of the belt are all biotite-bearing, usually of light color and of medium texture. The most important commercial granite deposit in this belt occurs in the northeastern part of Surry County near Mt. Airy. The famous "Mount Airy granite" is noted for its beautiful white color. It is composed essentially of quartz and feldspar with a very small amount of mica, zircon, epidote, and very little iron oxide. The minerals are so arranged that a very uniform color is to be had throughout the entire deposit.

The Appalachian Mountain granite area includes several of the mountain counties which lie between the Piedmont area and the Tennessee line. However, only three, Buncombe, Henderson, and McDowell, have shown a production during recent years.

Gneiss is a crystalline rock whose component minerals are essentially the same as granite but are arranged in parallel bands or layers. This rock made an important entry into construction in North Carolina more than one hundred years ago when the State Capitol was built of this type of rock which was quarried just east of Raleigh. In recent years there has been a renewed interest in this rock throughout the State.

GRANITE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Active Plants	Dimension Stone		Active Plants	Crushed Stone		Total	
		Short Tons	Value		Short Tons	Value	Short Tons	Value
1936	8	25,400	$ 360,465	65	2,372,030	$ 2,579,260	2,397,430	$ 2,939,725
1937	11	22,650	386,461	85	2,129,160	2,326,115	2,151,810	2,712,576
1938	10	31,260	472,240	90	3,180,170	3,892,237	3,211,430	4,364,477
1939	9	31,700	450,736	*	4,086,690	4,482,565	4,118,390	4,933,301
1940	10	15,760	289,499	*	2,387,130	3,836,019	2,402,890	4,125,518
1941	6	16,170	436,342	*	3,206,460	3,663,459	3,222,630	4,099,801
1942	7	14,830	221,011	*	2,557,150	2,964,216	2,571,980	3,185,227
1943	7	6,500	161,233	*	2,161,090	2,530,704	2,167,590	2,691,937
1944	8	9,930	276,579	*	1,401,980	1,682,609	1,411,910	1,959,188

*Not available.

Limestone and Related Rocks.—Limestone, either in the form of marble or the common compact variety, occurs as a series of narrow belts in parts of the Piedmont and Mountain areas of North Carolina. A belt of semi-crystalline limestone passes through Catawba, Lincoln and Gaston counties. In McDowell County, and also further west in Cherokee and Swain counties are comparatively narrow belts of marble. The limestones of the Piedmont Plateau and the Appalachian Mountains are found in Buncombe, Cherokee, Clay, Cleveland, Henderson, Transylvania, Macon, Madison, Mitchell, Gaston, Catawba, Jackson, Lincoln, McDowell, Yadkin, Swain, and Stokes counties.

THE MURPHY MARBLE AREA

The most extensive of the limestone and marble formations in the State is the Murphy marble which orms a narrow band extending northeastward almost continuously from Georgia along the valleys of the Nottely and Valley rivers for nearly the entire length of Cherokee County. After an interruption of a few miles, it reappears along the valley of Nantahala River in Swain County from Nantahala to Hewitts, where it pinches out. It also forms a group of narrow areas in the vicinity of Brasstown and Peachtree, east of Murphy, in Clay County.

The marble is 500 feet thick at its thickest known point and it has a known occurrence of more than 0 miles in length in Cherokee County. It is excellent stone for building, monumental, and decorative purposes. In Cherokee County it contains beds of white, blue, pink, and dark-banded dolomitic marble. The lue variety has the trade name "Regal Blue." Quarries have been opened on the marble throughout its outrop in the county.

The only producer of marble during the period under consideration was the Columbia Marble Company, operator of a quarry and finishing plant at Marble.

A narrow belt of marble and limestone parallels the Murphy Branch of the Southern Railroad betwee Nantahala and Hewitts. During most of the period under consideration, the Nantahala Limestone and Ta Company has operated a quarry and crushing plant at Hewitts, Swain County. Limestone from this are has been used chiefly for road metal.

MADISON COUNTY

The limestones (including marbles and dolomites) of Madison County consist of small lenses in th Carolina gneiss, larger lenticular beds in the Hiwassee slate, and the Shady dolomite.

Of the limestone deposits of Madison County, the Shady dolomite formation is the only one of mo than local interest. Quarries were formerly operated near Hot Springs but the activity during recent yea has been very small.

MITCHELL COUNTY

An unexploited deposit of marble or crystalline dolomite occurs in a schist member of the Caroli gneiss formation. It is best exposed in a cut of the Carolina, Clinchfield and Ohio Railroad on the east si of Toe River, 1¼ miles north of Bandana Station. At this point the dolomite is about 100 feet thick and h clear-cut, sharp contacts with mica schist on either side. The dolomite is white and coarsely crystallin Analyses show that it closely approaches the composition of pure mineral dolomite which contains 21.7 p cent MgO. It is conservatively estimated that the Bandana deposit contains at least 500,000 tons of hig grade dolomite.

MCDOWELL COUNTY

Dolomite and limestone are well exposed along both sides of the North Fork of the Catawba River, b tween Woodlawn and Linville Falls. The best exposure is at Linville Caverns, about 3 miles north of th Ashford railroad station.

For several years prior to the entry of the United States into World War II, a quarry was operated the Campbell Limestone Company, at Ashford. The American Asphalt Products Company, of Washingto D. C., operated an asphalt mixing plant adjacent to the crushing plant of the Campbell Limestone Compan

During the entire period under consideration the North Carolina Highway and Public Works Commi sion exploited a dolomite deposit on the south side of Turkey Cove, about ½ mile south of Woodlawn Po Office and ¼ mile east of the U. S. Highway 221 at a point 8½ miles north of Marion. For a part of th time production was at the rate of 400 tons per day.

HENDERSON, BUNCOMBE, AND TRANSYLVANIA COUNTIES

The limestone lenses in the Brevard schist are numerous between Brevard and Fletcher. They consi of fine to medium-grained crystalline rock nearly white in color. Quarry operations around Fletcher ha revealed a limestone lentil nearly 250 feet wide and more than a mile long. Quarries at the head of Boylst Creek show about 50 feet of limestone with a probable length of 1½ miles.

At various times small openings have been made in the limestone deposits of this area but the o important operation has been that of the Fletcher Lime stone Company at Fletcher. This company h produced crushed limestone over a period of years and constituted the only producer of lime in the Sta during the period covered by this report.

CLEVELAND AND GASTON COUNTIES

Crystalline limestone, or marble, forms a linear group of narrow bands extending northeastward fr the South Carolina line across the southeastern part of Cleveland County into Gaston County. It lies mile east of the town of Kings Mountain and pinches out about 1 mile west of Bessemer City.

Although several quarries have been opened at different times in this limestone belt, the most extensi development is near Kings Mountain, North Carolina, where the Superior Stone Company has carried extensive operations since 1940.

LINCOLN AND CATAWBA COUNTIES

Deposits of dolomitic limestone in Lincoln and Catawba Counties have been worked intermittently at different times over a long period of years.

During 1941 and 1942 the Setzer quarry, about 10 miles east of Newton, was operated by the Catawba Limestone Corporation, to meet local demands for agricultural and other limestone.

The Burgess Stone and Lime Company succeeded the earlier operator for a short time, but reported no production in 1944 or subsequent years.

YADKIN COUNTY

A deposit on the south side of the Yadkin River and about 2 miles upstream from Siloam Bridge, was worked during 1942 and 1943 by the State Highway and Public Works Commission.

COASTAL PLAIN AREA

Limestones and marls occur in varying amounts in Beaufort, Bertie, Bladen, Brunswick, Camden, Carteret, Chowan, Columbus, Craven, Currituck, Dare, Duplin, Edegcombe, Gates, Greene, Halifax, Hertford, Hyde, Jones, Lenoir, Martin, New Hanover, Northampton, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Pitt, Robeson, Sampson, Tyrrell, Washington, Wayne, and Wilson counties.

Many available analyses of the marls and limestones indicate that the calcium carbonate content is high and quite uniform. Those representing some 100 samples from the Trent River area have indicated a range of from 91.96 per cent $CaCO_3$ for the marl to 95.1 per cent for the limestone.

The major activity during the period under review was at Belgrade, Onslow County, where, during World War II, between 8 and 12 million tons of limestone were shipped from the large quarry of the Superior Stone Company. Activity was also reported at the Leon Simmons Pit, about 1 mile east of Pollocksville, Jones County, and near the Trent River. This pit was worked intermittently by prison labor for some years prior to 1941, as a source of concrete aggregate. New Hanover County also operated a marl pit for road metal about 1 mile west of the Castle Hayne-Wilmington Highway just south of Prince George Creek.

LIMESTONE PRODUCTION

The production of limestone in North Carolina for the period of 1936-1944, inclusive, is given in the accompanying tabulation. The average annual production for this period was 174,995 short tons, and the average annual value was $202,420, or $1.16 per ton. Of this quantity of stone, approximately 85 per cent was used for concrete and road metal. For the six years when a separation could be made, the average annual production of agricultural limestone was only 12,658 short tons, valued at $11,668, or $0.92 per ton. This quantity comprised slightly less than 8 per cent of all limestone produced and only 4 per cent of total agricultural limestone used in the State. For the same six years, the average annual quantity of limestone used for agricultural purposes in the State was 306,000 short tons, the remainder being shipped in, principally from Mascot, Tennessee, and Austinville, Virginia, where it is produced as a by-product in the concentration of zinc ores.

BROKEN AND CRUSHED LIMESTONE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Concrete and Road Metal		Agriculture		Total*	
	Short Tons	Value	Short Tons	Value	Short Tons	Value
1936	90,640	$ 98,359	**	$ **	90,640	$ 98,359
1937	132,180	126,277	2,410	1,395	134,590	127,672
1938	70,710	71,796	11,840	13,024	82,550	84,820
1939	215,090	232,012	3,050	4,620	218,140	236,632
1940	155,580	168,536	15,860	10,972	171,440	179,508
1941	172,180	192,944	28,830	23,173	201,010	216,117
1942	179,720	234,908	**	**	196,630	258,761
1943	91,920	122,573	13,960	16,823	161,520	227,807
1944	227,050	279,887	**	**	318,430	392,108

‡*Includes that used in rubble, railroad ballast, and for other purposes.
**Data not available.‡

Miscellaneous Stone.—In addition to granite, gneiss and limestone, other rocks were produced in Nor Carolina during the period under consideration. The quantity and value of these, however, constitute small part of the totals for the State. Marble is included under the "miscellaneous" heading in tabulatio as is the slate produced in the Denton area of Davidson County, and small quantities of sandstone and quar ite from several localities in western North Carolina. Many old mine dumps throughout the State ha been crushed and utilized in highway and other construction. Non-commercial stone has been utilized several power developments. A syenite-porphyry, occurring near Altamahaw, in Alamance County, was wi ly quarried during the earlier part of the period under review.

The accompanying tabulation shows production of other classes of rocks for the period under cons eration:

CRUSHED AND BROKEN STONE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1936–1944

YEAR	Trap (Or Related) Rock		Miscellaneous Stone	
	Short Tons	Value	Short Tons	Value
1936	90,100	$ 99,410	124,190	$ 148,313
1937	*	*	329,390	340,876
1938	58,700	54,603	593,720	536,691
1939	86,890	104,245	342,030	370,444
1940	240,000	272,000	201,200	209,316
1941	255,000	280,536	138,470	149,168
1942	42,120	72,203	105,970	133,373
1943	*	*	*	*
1944	*	*	*	*

*Cannot be revealed without disclosing confidential information.

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TALC, PYROPHYLLITE, AND SOAPSTONE

Talc.—Talc is a hydrous silicate of magneisum, containing 31.7 per cent magnesia, 63.5 per cent sili and 4.8 per cent water. It is characterized by its softness and its greasy feel. It is highly heat-resista yielding up its water completely only at high temperatures.

The uses of talc are many and varied; and few, if any, minerals surpass talc in their range of industr usefulness. The uses include paint, ceramics, roofing material, rubber, cosmetics, foundry facings, w tile, textiles, soap, wire insulation, lubricants, wall plaster, insulating material, crayons for making ca ings, paper filling, and others. About 92 per cent of the talc sold in this country is ground. It is genera sold on the basis of grain size and color.

Talc deposits of two different types have been known in North Carolina for many years. One of the is associated with altered basic igneous rocks such as peridotite, dunite, pyroxenite, and soapstone, wh the other is associated with marble. Some of the peridotite masses have been altered and contain, amo other minerals, varying amounts of talc and soapstone. For several years, small amounts of talc have be mined from some of these deposits and ground at different processing plants in the area.

In the period prior to World War II, there was some activity in Madison County. J. B. Bailey report some mining operations in the Laurel Creek District, and operated a mill at Marshall for a while.

The Western Carolina Talc Company, Asheville, was active for several years in the Marshall area, r porting mining operations at the Tipton, Shalton, Edwards, Brackens and Peters Cove mines, and operati a mill for the production of crayons and ground talc at Marshall.

The Bryson Talc Company operated some small prospects near Marion during 1941, and did some grinding. Victor Mica Company, Spruce Pine, Mitchell County, was also a producer of ground talc for a number of years.

Talc deposits associated with marble are found in the southwestern corner of the State, in Swain, Macon, and Cherokee counties. These bodies, which are replacement deposits in marble, vary in size from a few inches in length and width to masses more than 200 feet long and 50 feet thick. A detailed geological examination of the area, made cooperatively by the North Carolina Department of Conservation and Development and the Tennessee Valley Authority was begun in 1945. The results of this investigation are to be published as Bulletin 56 of the North Carolina Department of Conservation and Development. There has also been considerable exploration work carried on and talc is being mined by both open-cut and underground methods. The principal operation during recent years has been the Nancy Jordan Mine of the Hitchcock Corporation, 45 Patton Avenue, Asheville, and situated 1 mile southwest of Murphy. The Mulberry Gap Mine, 2 miles southwest of Murphy, was operated under license from the Tennessee Valley Authority by the Minerals and Metals Corporation, Murphy. The Mauney Mining Company, Murphy, carried out an extensive exploration program at the P. A. Mauney property near Kinsey. The Nantahala Talc and Limestone Company, of Andrews, produced talc from the Hewitt Mine in Swain County. A modern mill and crayon cutting plant is operated by the Hitchcock Corporation at the Nancy Jordan Mine.

Pyrophyllite.—Pyrophyllite bears a close outward resemblance to talc in its softness, color, feel, luster, and structure. Chemically it is a hydrous silicate of aluminum, containing theoretically 66.7 per cent silica, 28.3 per cent alumina, and 5.0 per cent water.

Important deposits of pyrophyllite occur along the eastern edge of the Piedmont Plateau—chiefly in Moore, Chatham, Randolph, Montgomery, and Alamance counties. The size of the bodies varies greatly, but the larger deposits are from 150 to 500 feet wide and 1,500 to 2,000 feet long. Among the more important uses of pyrophyllite are for toilet preparations, paints, refractories, plastics, insulation, bleaching, textiles, soap, lubricants, and as insecticide carriers.

Pyrophyllite refractories are manufactured at Pomona ,Guilford County, and are being shipped as far as Chicago, Illinois.

PRODUCERS OF PYROPHYLLITE IN NORTH CAROLINA IN 1945

NAME OF PRODUCER	ADDRESS	LOCATION OF MINE AND PLANT	
		Town	County
Carolina Pyrophyllite Co.	Staley, N. C.	Staley Glendon	Randolph Moore
North State Pyrophyllite Co.	Pomona, N. C.	Snow Camp*	Alamance
Standard Mineral Company	230 Park Ave., New York, N. Y.	Robbins**	Moore

*Plant located at Pomona
**Robbins was formerly Known as Hemp

PRODUCTION OF TALIC, PYROPHYLLITE, AND SOAPSTONE IN NORTH CAROLINA FROM 1936 TO 1945, INCLUSIVE

YEAR	Short Tons	Value	Average Value
1936	27,877	$ 280,026	$ 10.05
1937	28,250	271,013	9.59
1938	27,460	241,337	8.79
1939	36,772	283,789	7.72
1940	39,206	298,382	7.61
1941	64,783	567,921	8.77
1942	56,909	503,082	8.84
1943	65,698	580,106	8.83
1944	69,892	645,156	9.23
1945	77,529	675,789	8.72

For the period of 1936-1945 the average annual production of talc, pyrophyllite, and soapstone in North Carolina was 49,438 short tons; average annual value was $434,660; and, average value per ton was $8.79. During this period the State's production was 15 per cent of the National total on the basis of tonnage, and 11 per cent on basis of value.

Practically all of the pyrophyllite produced in the United States is from North Carolina. In 1942 the pyrophyllite production was 53,669 short tons valued at $414,816; in 1943 it was 62,142 tons valued at $494,791. A breakdown of production figures is not available for subsequent years.

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VERMICULITE

The term "vermiculite" is applied generally to a group of hydrated aluminum magnesium iron silicates which have micaceous cleavage and a peculiar quality of exfoliation with intense heat. The exfoliation probably results from warping of the individual micaceous laminae, possibly assisted by expansion of the water of hydration freed by the heating process. The expansion is so great that the untreated mineral weighing 100 pounds per cubic foot will weigh only 6 to 20 pounds per cubic foot after heating.

The uses to which exfoliated vermiculite has been put may be listed under two groups; first, those dependent on the bright bronze color of the material; and, second, those dependent upon its extreme lightness and its heat insulating and accoustical properties. The brighter colors of ground and exfoliated vermiculite are used in pigments and inks in place of powdered bronze, as a paint pigment or kalsomine, and as a decorative material on wall paper.

The exfoliated vermiculite is an excellent heat insulator. It is used as loose fill in walls and over ceilings to insulate houses. Vermiculite finds uses in plastics, heat-insulating bricks, pipe and boiler coverings, light-weight concrete aggregate, as a filler for insecticides, and as a soil conditioner.

The North Carolina deposits occur associated with basic magnesian rocks from Clay County northeast to Avery County. The principal development has been in the Ellijay district of Macon County and near Swannanoa, Buncombe County. Most of the North Carolina vermiculite is believed to have been derived from the alteration of chlorite. The largest and most persistent of the vermiculite veins and lenses are found either in peripheral zones around the basic masses at their contact with the enclosing gneisses and schists, or in veins within them.

During the field season of 1941, the North Carolina Department of Conservation and Development, in cooperation with the Tennessee Valley Authority, carried out a detailed investigation of the deposits in the State. Vermiculite reserves were estimated to total between 212,000 and 440,000 short tons. Results of this investigation are published as Bulletin 50 of the North Carolina Department of Conservation and Development.

The vermiculite production of North Carolina, for years in which it is possible to segregate the State total, was as follows:

SCREENED AND CLEANED VERMICULITE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1939–1942

YEAR	Short Tons	Value	Value Per Ton
1939	1,400	$ 14,400	$ 10.29
1940	1,040	8,070	7.76
1941*	--------	--------	--------
1942	1,612	19,048	11.75

*Data not available.

VERMICULITE MINES IN OPERATION IN NORTH CAROLINA IN 1940–1942

OPERATOR	POST OFFICE ADDRESS	MINE	LOCATION	COUNTY
Bee Tree Vermiculite Mines	Asheville	Bee Tree	Sawnnanoa	Buncombe
Cary Minerals Company	Ellijay	Ammons	Ellijay	Macon
Philip S. Hoyt	Franklin	Corundum Hill	Gneiss	Macon
R. G. LeTourneau Company	Toccoa, Ga.	Corundum Hill	Gneiss	Macon
Minerals, Inc.	Franklin	Angel	Ellijay	Macon
		Mincie	Ellijay	Macon

OPERATORS OF VERMICULITE PLANTS IN NORTH CAROLINA IN 1942

OPERATOR	PLANT	ADDRESS	LOCATION	OPERATIOB
Bee Tree Vermiculite Mines	Asheville	Bee Tree	Swannanoa	Screening and Exfoliation
Cary Minerals Company	Ellijay	Ammons	Ellijay	Screening
Minerals, Inc.	Franklin	Franklin	Franklin	Screening and Exfoliation

During more recent years the only operations have been those of Minerals, Inc., later known as Vercalite Industries, Inc.

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U. S. Bur. Mines: Minerals Yearbook, 1936–1944.

ZIRCON

Zircon is a silicate of zirconium having a theoretical zirconium content of 67.2 per cent. It is usually of a grayish, light brown to reddish brown color. Occasionally it is colorless to red and perfectly transparent.

Zircon is used in ceramics, chiefly as an opacifier in porcelain enamels and pottery glazes, as a constitu-nt of refractories, electrical and chemical porcelains, grinding balls, and resistant glasses. Zirconia is advantageous in electrical heating units because it is both a conductor of heat and an insulator of electricity. One of the largest uses of zircon is as a foundry sand. Zirconyl sulphate is a white tanning agent comparable with or superior to chrome. Zirconium metal, the most explosive metal powder, is used in radio tubes, blast-ng caps, and flares. Metallurgical zirconium is a deoxidizer and scavenger; and small additions to certain teels are said to improve hot working properties, surface characteristics, and impact strength. Zirconium-opper is a promising alloy that combines high heat conductivity and tensile strength.

The principal occurrence of zircon in North Carolina is in Henderson County, near Tuxedo (Zirconia). ircon has been found also near Mars Hill, Madison County, near New Sterling, Iredell County, and near eddis River in Wilkes County. It also occurs in the pegmatites and pegmatized gneisses of the monazite egion of North Carolina and South Carolina.

On account of the low price and competition from foreign countries there has been no production of rcon in North Carolina since 1911, in which year it amounted to 3,208 pounds valued at $802. During he war period, some prospecting of the dike near Lake Summit, Henderson County, was carried out but no evelopment followed.

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MINOR MINERALS

Many important minerals are found in North Carolina which are not present in sufficient quantities be mined economically. Limited production of some could be expected under more favorable economic co ditions; others are exceedingly rare. Such minerals are generally referred to as minor minerals. Amo some of these are beryl, graphite, platinum, sericite, tantalite (and columbite), and uranium.

BERYL

Beryl, or beryllium aluminum silicate, is produced on a small scale in North Carolina, as a by-product the mining of the pegmatites for mica and feldspar. Production totals only a few tons each year and is fro a number of small mines; it is doubtful if the State will ever be able to make any important contribution this very useful but scarce mineral.

GRAPHITE

Graphite is a crystalline form of carbon, chemically the same as diamond and charcoal. Natural graph is known to occur at many localities within the area of crystalline rocks in central and western North Ca lina. Several decades ago an effort was made to work a deposit near Graphitesville, McDowell County, a there is a record of a small production from Macon, Yancey, and Catawba counties. No production has be reported since 1916. A graphite schist was worked many years ago in Wake County.

PLATINUM

The occurrence of grains of platinum among the sands of gold-washing in Rutherford and Burke cou ties was reported many years ago. It has also been found on Brown Mountain, in Burke County, northw of Morganton; and, near Burnsville, Yancey County. A belt of platinum-bearing rock is reported as exte ing from Cedar Falls, North Carolina, to Danville, Virginia.

SERICITE

Sericite is a potassium aluminum silicate occurring as a secondary muscovite. It has been used as insecticide carrier and experimentally as an ingredient of welding rod coatings. It also offers possibilities a flux in ceramic bodies.

Sericite schist occurs in a number of localities in North Carolina. The best known occurrences are association with some of the pyrophyllite deposits in the Deep River area of Moore and Chatham counti Other deposits occur 1 mile north of Cedar Falls, Randolph County, and in Penley Cove, 4½ miles from B more Station, Buncombe County.

TANTALITE AND COLUMBITE

These minerals are ores of tantalum and columbium, metals closely related in occurrence and use. Ta talum is used in vacuum tubes, as catalysts, in high-speed cutting tools, and in surgery. Columbium's ma use has been as an addition agent to stainless steels, acting as a stabilizer and imparting greater resista to corrosion.

Small quantities of tantalite and columbite have been produced in North Carolina; the production h been only a few hundred pounds per year and has been obtained as a by-product of mica and feldspar m ing. Columbite crystals in parallel position with samarskite crystals have been found at the Wiseman M Mine, Mitchell County. It also occurs sparingly in small crystals at the Deake and other mines in Mitch County. At the Ray Mine, near Burnsville, Yancey County, some very large well-developed crystals of lumbite have been obtained. The occurrence of columbite in these localities is in pegmatite dikes. Columb has also been found near Franklin, Macon County; White Plains, Alexander County; Balsam Gap Mine, Bu combe County; and Brindletown, Burke County. Massive tantalite occurs in some quantity near Mine Fo Yancey County.

RADIOACTIVE MINERALS

At many of the mica mines in western North Carolina, uranium minerals have been sparingly found, as the Flat Rock Mine near Spruce Pine, Mitchell County, where uraninite has been found in masses weighing up to three pounds. These masses, however, were largely altered to gummite and uranotil. This mine has produced the larger amount of uranium mineral produced in North Carolina. At the Deake Mine, also near Spruce Pine, there is a similar occurrence of uraninite and gummite. At the Thompson Mine, near the Deake, a mass of uraninite and gummite was found that weighed two pounds. Uranophane has been observed at many more of the mica mines in this vicinity, and other parts of Mitchell, Avery, and Yancey counties. Uranium minerals have also been found sparingly at the Wiseman Mine, Mitchell County, and the Ray Mine, Yancey County.

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MINERAL FUELS

COAL

The Deep River Coal Field.—The Deep River Coal Field is located in parts of Chatham, Lee and Moore counties, and lies along the Deep River some 50 miles southwest of Raleigh and about 10 miles northwest of Sanford. This field has been known for about 150 years and numerous efforts have been made during the past 90 years to develop it.

The coal beds of the Deep River field occur in the Cumnock formation, a part of the Triassic sandstones and shales which outcrop in a comparatively narrow belt from Oxford near the northern boundary of the State, to the South Carolina line near Wadesboro. While coal has been reported at many places in this belt, the only known coal of commercial importance is found on Deep River, west and northwest of Sanford. Here a shallow synclinal or trough-like field is estimated to contain approximately 70,000,000 tons of recoverable coal. The beds range in thickness from 30 to 48 inches and apparently average 40 inches. The coal is, in general, jet black with few if any dull bands. It has a highly developed cleavage, the chief planes of which are at right angles to the strike of the bed.

The coal in this field is of a bituminous character, and contains 30 to 35 per cent of volatile matter, 55 to 60 per cent fixed carbon, 6 to 9 per cent ash, and has a heating value of approximately 14,000 B.t.u.

Practical tests have established it as having excellent coking qualities. A large sample of washed coal from this field was tested at the U. S. Bureau of Mines, Experiment Station, Pittsburgh, Pennsylvania, to determine its coking properties and possible by-products which it would yield in the process. An analysis of the washed coal is as follows:

PROXIMATE ANALYSIS

	Coal Per Cent	Coke Produced Per Cent
Moisture	1.0	0.5
Volatile Matter	33.0	3.8
Fixed Carbon	59.6	87.2
Ash	6.4	8.5

ULTIMATE ANALYSIS

	Coal Per Cent	Coke Produced Per Cent
Hydrogen	5.2	1.2
Carbon	78.9	86.0
Nitrogen	2.1	2.0
Oxygen	5.8	1.0
Sulphur	1.6	1.3
B. T. U.	14,220	13,550

The result of coking tests on the coal was as follows:

Final coking temperature	775.. to 800.. C.
Coke Yield	75 per cent of charge
Gas Yield	8000 cu. ft. per ton of coal
Ammonium Sulphate	23 lb. per ton of coal
Tar (dehydrated)	22 gal. per ton of coal

The report further shows the by-product yield of the coal to be entirely satisfactory and to compare favorably with yields from Freeport, Pennsylvania, coal and the coke to be of very good quality fully equal in all respects to Freeport or Pittsburgh cokes.

Activity in the Deep River Coal Field between 1936 and 1940 consisted of some small-scale operations producing small tonnages for local domestic use. During 1940 such operations were reported by Deep River Coal, Inc., and Sanford and Reeves Coal Company, both of Sanford. In the summer of 1941 Coal Products, Inc., also of Sanford, was organized and began dewatering operations preparatory to reopening the old Carolina Coal Mine at Cumnock, employing a firm of coal mining engineers from West Virginia to open up and operate the mine.

Early in 1943 an investigation was made by the H. A. Brassert and Company, for the State of North Carolina, to determine the possibilities of using Deep River coal in the manufacture of sponge iron. The Brassert Report, on open file in the Department of Conservation and Development, was favorable and recommended the establishment of coking plants to utilize the coal. In April, 1944, the U. S. Bureau of Mines began exploratory drilling in the area; and by the end of October four holes had been completed. Drilling was renewed in April, 1945, and two additional holes were completed by August of that year. The Walter A. Bledsoe Company of Terre Haute, Indiana, began a program of exploratory drilling late in June, 1945, and plans were made to develop the field.

The coal consumption in the potential markets within a radius of 150 miles from the coal field is over 3,000,000 tons annually. This territory contains cities with a combined population of over 600,000. Coal shipped from this field to North Carolina cities has a freight differential of $1.25 to $2.41 per net ton in its favor as compared to freight rates on coal from competing points outside the State. The construction and operation of coke plants to utilize the Deep River coal is an outstanding industrial opportunity in North Carolina.

The Dan River Coal Field.—Another area in North Carolina, known as the Dan River Coal Field, lying along Dan River and Town Fork in Rockingham and Stokes counties, was investigated some years ago by geologists of the U. S. Geological Survey. After a thorough and careful examination of the Triassic beds in this field the conclusion was reached that there is no reason to expect to find commercially valuable coal beds in this district. The beds of semi-anthracite found near Walnut Cove and near Leaksville are only a few inches thick and of small lateral extent.

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PEAT

The term "peat" is used to describe the partly carbonized organic residuum produced by an arrest in the decomposition of trees, twigs, seeds, shrubs, mosses, and other vegetable remains covered by or saturated with water. Its vegetable structure is generally visible to the naked eye and it contains a large part of the carbon of the original vegetable matter. It is usually acidic and contains little inorganic matter.

North Carolina has a wide area of coastal plain that contains numerous swamps and lagoons, and in these, deposits of peat of sufficient extent to be of commercial importance are found. The largest area in the State is that of the Dismal Swamp, lying partly in Virginia and partly in North Carolina. In the North Carolina portion deposits of peat are found in Perquimans, Pasquotank, Camden, and Currituck counties. In Currituck County two areas have been analyzed as follows:

Proximate		
Moisture	8.23	
Volatile	52.05	56.72
Fixed Carbon	33.54	36.55

Ultimate		
Ash	6.18	6.73
Sulphur	.26	.28
Nitrogen	1.60	1.74

Just on the outskirts of Elizabeth City there is an area of good grade peat averaging from 14 to 18 feet thick. In Craven County there are deposits of peat that were worked from 1918 to 1922. In Sampson County near the main line of the Atlantic Coast Line Railroad from Wilmington to Fayetteville is a large acreage of peat. Analyses of this peat are as follows:

Proximate	
Moisture	11.25
Volatile Matter	52.15
Fixed Carbon	34.90
Ash	1.70

Ultimate	
Nitrogen	1.09
P_2O_5	trace
K_2O	.04
Moisture	10.05
Ash	1.7

Various companies mined peat during and following the first World War. However, there has been no production reported since 1922. The peat produced in North Carolina went largely into the manufacture of fertilizer.

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EXPLORATION FOR PETROLEUM AND NATURAL GAS IN NORTH CAROLINA

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The history of the exploration for oil and gas in North Carolina can be divided into two periods: From 1911 to 1945, and that since 1945.

During the first period, five holes were drilled for oil and gas; and two deep holes, which tested fairly deep sections, were drilled for water. In 1911 the East Coast Drilling Company drilled three holes about 3½ miles northeast of Coinjock, Currituck County. It is reported that these holes reached depths of 377, 764 and 855 feet. No samples are available and only vague drillers logs are left.

The Great Lakes Drilling Company in 1924 and 1925 created considerable interest in drilling for oil on the shore of Ellis Lake about 5 miles west of Havelock, Craven County. This well was logged by W. C. Mansfield of the United States Geological Survey and the report published as Economic Paper No. 58 of the North Carolina Department of Conservation and Development in 1927. The field notes of W. H. Butts report "small show of gas at 336 . . . gas show began around 720 to 725 feet." No show of oil is recorded at any depth in the Mr. Butts' notes. This hole cut basement rocks at 2,318 feet (—2,288 feet).

In 1927 a hole was drilled near Clinton, Sampson County, which, according to H. J. Bryson in Economic Paper No. 63, p. 146, of the North Carolina Department of Conservation and Development (1930), reached a depth of 600 feet. Local reports gave the well a depth of about 730 feet and a report of more than a show of oil. However, other local reports indicate the well was salted with Pennsylvania crude.

The Clarendon Water Works drilled for water in 1911 in Hilton Park, Wilmington, New Hanover County. This hole cut the basement granite at 1,330 feet (—1,321 feet) but, although it penetrated the entire seidmentary section, it showed no evidence of oil or gas. The water below 500 feet was unsatisfactory. The United States Army the same year drilled for water at Fort Caswell, Brunswick County. This hole cut the granite at 1,543 feet (—1,533 feet) and did not show any oil or gas. The water is warm and not too potable. Of these holes, only the last two penetrated the entire sedimentary section.

The coal basin in the Deep River Valley around Gulf and Cumnock was thought to have possibilities as the coal is somewhat gassy. However, diamond drill holes only got vague shows of gas below igneous sills.

In 1927, F. C. Vilbrandt wrote "Oil-bearing Shales of the Deep River Valley," published as Economic Paper No. 59, North Carolina Department of Conservation and Development. The shales yield from 11 to 45 gallons of shale oil per ton, or an average of 25 gallons; 8.46 pounds of ammonium sulphate; and 1,900 cubic feet of gas. No work has been done on these shales since. However, seventeen diamond drill holes have been drilled in the Deep River Coal Field in recent years but have showed no commercial gas or oil and no satisfactory structures to trap any oil or gas.

In 1937 a Mr. Lamb employed a local well driller to drill an oil well near Pamlico, Pamlico County. It is reported that the hole was abandoned at 45 feet.

The second period of exploration was preceded by scientic investigation before drilling was started. Beginning in the middle 1930's, geophysical work was carried on from New Jersey to Florida. With the discovery of oil in Florida additional interest was shown in the Atlantic Coastal Plain and investigations were renewed in North Carolina. The State lands north of a line drawn from Washington, Beaufort County, to Cape Hatteras, Dare County, and east of the 77 Meridian, were leased to the Standard Oil Company of New Jersey. The State lands south of a line from New Bern, Craven County, to Ocracoke Inlet, were leased to the Coastal Plains Company of Kinston, North Carolina. A wedge of land was retained by the State for future leasing. Private lands were leased by most of the major companies and by three local companies as follows: The Coastal Plains Company, the Tidewater Petroleum Company of Kinston, and the Carolina Petroleum Company of Durham. There were some personal leases held by various private citizens.

The major oil companies and local companies had various amounts of geophysical work done and made drilling locations on the basis of this work.

The Coastal Plains Company began operations in 1945. They arranged for F. L. Karston to bring in a rig and drill Laughton No. 1, 3 miles northwest of Morehead City and 4 miles south of Harlow, Carteret County, on the south bank of Newport River. This hole was started in May, 1945, and abandoned in June at a total depth of 4,044 feet. It cut the granite basement at 4,030 feet (—4,013 feet). No oil or gas was reported.

The Standard Oil of New Jersey brought in a heavy rig and, in June, 1945, began drilling a few hundred yards from the old Hatteras Lighthouse near Buxton, Dare County. This hole, known as Hatteras Light, reached a total depth of 10,054 feet. Sediments were recorded to a depth of 9,978 feet (—9,860 feet), where the basement granite was penetrated. Various sands were encountered but no evidence of oil or gas were found.

The Carolina Petroleum Company began drilling near Merrimon, Carteret County, in 1946, and drilled five holes. The Guy M. Carraway No. 1, abandoned at 4,069 feet in July, 1946, cut the basement granite at 4,054 feet (—4,036). The Nita Carraway No. 1 reached the granite at 4,120 feet (—4,105 feet) and was abandoned in August 1946, with a total depth of 4,126 feet. The D. L. Phillips No. 1, cut the granite at 3,94 feet (—3,935 feet) and was abandoned in September, 1946, at a total depth of 3,964 feet. The H. B. Salter No. 1 cut the granite at 3,955 feet (—3,941 feet) and was abandoned in October, 1946, at a total depth of 3,963 feet. Side wall samples taken from this well by the Schlumberger Well Surveying Corporation were reported to give slight odors of oil at several places, but drill stem tests failed to produce any oil show. The John Wallace No. 1 cut the granite at 4,020 feet (—4,010 feet) and was abandoned in December, 1946, at a total depth of 4,025 feet. Slight evidence of oil is reported for this hole.

The Charles Bryan No. 1 was drilled by the Carolina Petroleum Company about 1.5 miles east of the Great Lakes Drilling Company's hole on Ellis Lake (1924-1925) and about 4.5 miles west of Havelock, Craven County. This hole cut the basement granite at 2,408 feet (—2,361 feet) and reached a total depth of 2,435 feet. It was abandoned in January, 1947, with no evidence of oil or gas. The North Carolina Pulpwood No. 1 was drilled about 1 mile west of the town of Pamlico, Pamlico County. This hole reached a total depth of 3,667 feet and cut the basement (slates) at 3,658 feet (—3,647 feet). It was abandoned February 25, 1947. The rig was moved 1.2 miles farther west and the Atlas Plywood No. 1 was drilled to a depth of 3,425 feet, cutting the basement at 3,414 feet (—3403 feet). This hole was abandoned on March 21, 1947.

In the fall of 1946 the Standard Oil of New Jersey brought in a drilling barge and set up location in Pamlico Sound about 10 miles south of Wanchese, Roanoke Island, Dare County. This hole (North Carolina Esso No. 2) was abandoned at a total depth of 6,410 feet (—6,389) while still in sediments.

H. B. Salters No. 1 and John Wallace No. 1 (Carolina Petroleum Company) have been reported as having some evidence of oil and gas. All the other holes are reported without any cored evidence. These eleven holes, drilled since 1945, have been electrically logged and samples collected and turned over to the State of North Carolina, along with the electric logs. These logs indicate that a much thicker section of sediments exists than was realized before. They do not give any definite evidence of structure but rather indicate that oil and gas possibilities lie in stratigraphic traps. However, there are too few holes drilled to definitely rule out structure.

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EXAMINATION OF MINERAL SPECIMENS

Samples of any mineral found in the State may be sent to the Department of Conservation and Development, Raleigh, North Carolina, for identification, and the same will be classified free of charge. Samples should be in lump form, if possible, and marked plainly on outside of package with name of sender, post-office address, etc.; a letter should be sent but not in the same package as the sample. A stamp should be enclosed for reply.

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ECONOMIC PAPER NO. 66

THE MINING INDUSTRY IN NORTH CAROLINA FROM 1946 THROUGH 1953

BY

SAM D. BROADHURST
ASSISTANT STATE GEOLOGIST

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LETTER OF TRANSMITTAL

Raleigh, North Carolina
June 10, 1955

To His Excellency, Honorable Luther H. Hodges
Governor of North Carolina

Sir:

I have the honor to submit herewith manuscript for publication as Economic Paper No. 66, "The Mining Industry in North Carolina from 1946 through 1953," by Sam D. Broadhurst.

This report contains a summary and review of the mining industry in North Carolina for the years 1946 through 1953. In addition, it contains a brief review of mining in the state for the past fifty years and presents information of value on the geology and potential mineral resources of the state. There is an increasing demand on the part of mineral producers for information on metals, industrial minerals and rocks, and mineral fuels. It is believed that this report contains information of value to mineral producers.

Respectfully submitted,

Ben E. Douglas,
Director

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THE MINING INDUSTRY IN NORTH CAROILNA FROM 1946 THROUGH 1953

By Sam D. Broadhurst
Assistant State Geologist

ABSTRACT

The interval from 1946 through 1953 represents a period of major achievement by the mining industry in North Carolina. Stimulated by a highly favorable economy, new records in volume and value of production were attained. By volume, production rose from approximately eleven million tons in 1946 to more than eighteen million tons in 1953, an increase of about 64 percent. The total value of the state's mineral production in 1946 was $14,947,000; in 1953, the total value was at an all-time high of $38,458,000, representing an increase of 157 percent. For the eight-year period, the average annual value of minerals produced was $24,810,850, which is 56 percent higher than for the previous five-year period, 1941-1946. The apparent lag in volume as compared with value was caused in part by a general rise in prices, but a major factor was the increased production of high-value, low-tonnage mineral concentrates, notably tungsten.

During the period under review, there was widespread activity throughout the mineral industry. Detailed geologic studies and exploratory programs were carried out in many areas. There were major advances in the technology of mineral beneficiation, and many new mining and ore-treatment methods were employed. Production facilities were expanded rapidly in most segments of the industry. Among the more significant developments were the rapid rise in the production of lithium and tungsten minerals, a major expansion of the stone, sand, and gravel industries, establishment of lightweight aggregate plants, the erection of additional feldspar flotation plants, the revival of sheet-mica mining, and the large exploratory programs carried out in search of economic amounts of petroleum, coal, spodumene, monazite, ilmenite, and raw materials for the manufacture of Portland cement. There was a sharp revival of interest in prospecting for metals, and considerable activity was manifested in the search for radioactive minerals.

INTRODUCTION

This report presents data dealing with the activities of the mineral industry in North Carolina from 1946 through 1953. It is one of a series of such reports published by the state's geological survey since 1900 and is designed to make available information concerning the mineral resources of North Carolina and to present important facts connected with their development. In it, are brief descriptions of the commercial minerals found in the state, their uses, geographic distribution, geologic occurrence, historical notes, and production statistics. A geologic map and several mineral maps, showing the distribution of the principal mineral localities, are included.

ACKNOWLEDGMENTS

Economic Paper 66 was prepared under the general direction of the State Geologist Jasper L. Stuckey. It is a compilation of information from many published and unpublished sources from which the writer has drawn freely. Included, are reports of the United States Geological Survey, United States Bureau of Mines, Tennessee Valley Authority, North Carolina State College's Minerals Research Laboratory and Department of Engineering Research, various articles in technical literature, from the files and published literature of the Division of Mineral Resources of the North Carolina Department of Conservation and Development, and information freely given by the many mine and mill operators throughout the state. Statistics have been compiled from data collected by the United States Bureau of Mines for its annual publication, Minerals Yearbook.

HISTORICAL SKETCH

Mining in North Carolina dates from prehistoric time and since colonial days has been an important factor in the economy of the state. During and immediately following colonization of the territory, emphasis was restricted primarily to the search for base and precious metals. An iron industry, consisting of many small furnaces scattered throughout the central and western parts of the state, flourished during the eighteenth and nineteenth centuries and was a stabilizing factor in the early development of North Carolina. Copper, lead, silver, and coal were mined also. Prior to discovery in California, this state was a leading producer of gold. Clays, mica, and various types of stones were among the important nonmetallic materials produced. A lack of readily available reserves and the discovery of large deposits elsewhere resulted in a rapid decline in metal mining in North Carolina. With the changing economy of the latter part of the nineteenth century, the production of nonmetallic or industrial minerals increased rapidly and now dominates the industry. In recent years, interest in metals has been revived by the discovery of commercial deposits of tungsten and ilmenite, and a general appraisal of the state's metal resources has been under way since World War II.

The present mineral industry is a highly diversified one and produces many critical and strategic minerals. North Carolina is a leading producer of tungsten and lithium ores, sheet and flake mica, feldspar, pyrophyllite, and primary kaolin or china clay. Crushed and dimension stone, sand and gravel, talc, pyrophyllite, structural clays and shales, ilmenite, olivine, and other materials are mined in quantity. Mineral production has risen steadily since 1900 and within the past few years has advanced at a rapid pace, in general paralleling economic trends throughout the United States.

By 1946, the nation's economy had been released from the rigid restrictions imposed by World War II and was expanding rapidly to meet consumer demands. In 1950, military needs dictated by war in Korea and by other international conditions were superimposed upon an already inflated economy. The resulting mammoth increase in industrial capacity made heavy demands upon raw materials to meet production schedules. These events are dramatically reflected in the growth of the mineral industry of North Carolina and are pointed reminders of the ever increasing importance of mineral resources to the general welfare of the state.

THE MINERAL INDUSTRY

The period from 1946 through 1953 is one of considerable achievement by the mineral producers of North Carolina. Perhaps at no other time has as much emphasis been placed upon scientific research as a tool for mineral development. With highly favorable market conditions as an incentive, considerable time and effort were spent by the industry, in cooperation with various state and federal agencies, in appraising accurately the mineral resources of the state as a whole and in determining the most practical methods for their development. The rapid growth of the industry during the past few years indicates that this work has been very successful.

STATISTICAL REVIEW

During the interval 1946-1953, mineral output in North Carolina was the greatest ever recorded. Tonnage rose from approximately eleven million in 1946 to more than eighteen million in 1953, reaching an all-time high of about twenty-one million in 1952. Tonnage figures are based upon mill output and are good indexes in appraising trends in some phases of the industry; however, when compared with total value of mineral products, the relationship does not always appear consistent. This is a result of the production of relatively small amounts of high-value mineral concentrates, such as sheet mica and tungsten.

The total value of minerals produced in North Carolina increased from $14,947,000 in 1946 to $38,458,000 in 1953, an increase of 157 percent. For the eight-year period, the average annual value was $24,810,850 as compared with $15,980,000 for the preceding five-year period. The significance of this increase is apparent in Figure 1, which presents graphically the annual value of minerals produced in North Carolina from 1900 through 1953.

As is shown in Figure 2, nonmetallic minerals dominated production. The metals, especially titanium and tungsten, made important contributions, and by the end of the period, tungsten had become one of the leading mineral products of the state. Of the annual average value for the eight-year period, stone accounted for

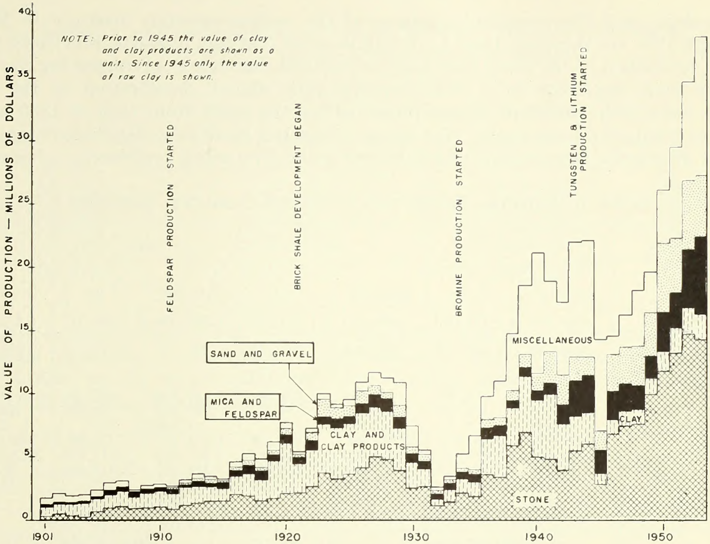

Figure 1. Annual Value of Minerals Produced in North Carolina, 1900-1953.

43.6 percent; sand and gravel, 16.9 percent; clay and shale, 7 percent; talc and pyrophyllite, 6.3 percent; feldspar, 6.3 percent; and mica, 5.9 percent. Tungsten, ilmenite, and miscellaneous mineral products accounted for approximately 14 percent.

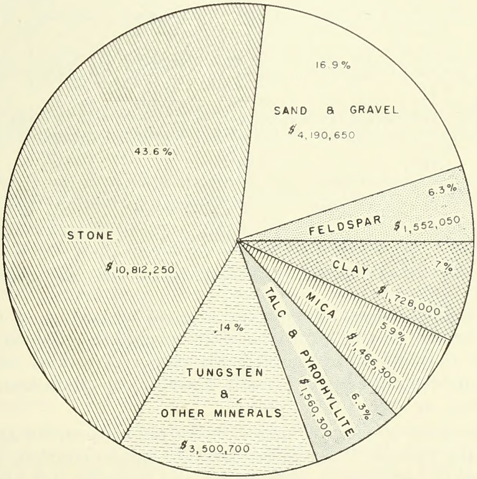

Figure 2. Average Annual Value of Mineral Production by Commodity in North Carolina, from 1946 through 1953.

The itemized values—and where possible tonnages—of the various minerals produced in North Carolina from 1946 through 1953 are shown in Table I. It will be noted that clay products, previously included in the value of mineral production of the state, have been deleted and that figures presented for clay represent the value of raw clay, shale, and kaolin only. This conforms with similar classification by the United States Bureau of Mines since 1950; therefore, figures presented for the years from 1946 to 1950 are lower than those published currently for those years. The group of minerals listed as undistributed represents those for which individual production figures cannot be published without revealing confidential information.

TABLE I. MINERAL PRODUCTION IN NORTH CAROLINA, 1946-1953

	1946		*1947*		*1948*		*1949*	
	Quantity#	*Value*	*Quantity#*	*Value*	*Quantity#*	*Value*	*Quantity#*	*Value*
Clays	914,999	$ 1,178,030	1,068,572	$ 1,314,976	1,205,000	$ 1,436,417	1,181,047	$ 1,335,954
Coal							14,000	104,000
Feldspar (long tons)	230,367	1,200,638	220,997	1,081,514	201,774	1,116,825	160,916	973,431
Gold (troy ounces)							13	1,000
Mica								
Scrap	39,100	887,901	38,665	884,068	44,428	992,263	24,801	640,374
Sheet (pounds)	424,791	135,505	210,816	84,275	257,926	44,678	470,072	121,270
Olivine	6,249	*	7,938	*	3,926	*	2,458	*
Sand and Gravel	4,213,795	2,993,711	4,172,000	2,956,800	4,837,437	3,522,403	5,092,929	3,553,180
Stone	4,505,880	6,835,448	5,018,000	7,561,167	5,237,050	7,713,859	6,225,290	10,077,976
Talc and Pyrophyllite	87,718	976,524	97,484	1,186,463	104,052	1,455,691	86,208	1,344,767
Titanium Concentrate	17,852	*	27,199	*	28,790	*	31,714	*
Tungsten Concentrate	307	*	538	*	965	*	770	*
Undistributed†		739,481		1,316,009		1,948,864		1,603,048
TOTAL		$14,947,238		$16,385,272		$18,231,000		$19,755,000

	1950		*1951*		*1952*		*1953*	
	Quantity#	*Value*	*Quantity#*	*Value*	*Quantity#*	*Value*	*Quantity#*	*Value*
Clays	1,437,000	$ 1,766,785	1,462,155	$ 2,177,515	1,357,700	$ 2,080,172	1,466,232	$ 2,534,908
Coal								
Feldspar (long tons)	183,027	1,107,061	166,361	1,230,404	240,364	2,416,031	268,042	3,290,495
Gold (troy ounces)								
Mica								
Scrap	48,193	1,281,584	52,550	1,441,886	58,576	1,551,071	55,814	1,520,381
Sheet (pounds)	483,736	102,179	464,949	127,204	595,331	664,075	503,333	1,229,613
Olivine	4,537	*	*	*	*	*	*	*
Sand and Gravel	8,352,475	5,465,067	7,656,370	4,435,702	8,724,748	5,665,169	6,910,982	4,992,991
Stone	7,711,580	11,894,745	8,612,967	13,292,690	9,647,522	14,694,698	9,317,390	14,424,323
Talc and Pyrophyllite	116,895	1,855,163	113,950	1,982,927	115,481	1,771,518	118,614	1,909,027
Titanium Concentrate	25,842	*	32,100	*	25,328	*		
Tungsten Concentrate	1,240	*	1,041	*	1,254	*	2,120	*
Undistributed†		2,870,416		4,957,672		5,888,209		8,486,612
TOTAL		$26,343,000		$29,646,000		$34,730,943		$38,458,350

* Figures cannot be published without revealing confidential information.

Quantity is given in short tons except as noted.

† Includes abrasive stones, asbestos, beryl, lithium concentrates, tantalum concentrates, vermiculite, marble, quartz, tin, and other minerals.

In terms of value, North Carolina's contribution to the mineral production of the United States is small. Although complete statistics are not available for the entire period reviewed by this report, for the years between 1946 and 1951, North Carolina ranked thirty-sixth among the states and accounted for only 0.23 percent of the nation's total. In terms of relative growth, however, the state has continued to increase at a rate greater than has the nation, as is shown in Table II.

In a move to stimulate production of domestic materials for the national stockpile, the United States Government established in 1950 the Defense Minerals Exploration Administration, an agency designed to aid financially persons and industrial concerns in prospecting and exploring for various strategic and critical materials. All geologic and engineering field activities necessary to carry out the program effectively are provided jointly by the United States Geological Survey and the United States Bureau of Mines. The Defense

TABLE II. AVERAGE ANNUAL VALUE OF MINERAL PRODUCTION OF NORTH CAROLINA AND OF THE UNITED STATES, 1906-1951

Years	*North Carolina*		*United States*	
	Average Annual Value	*Growth* 1906—15=100	*Average Annual Value*	*Growth* 1906—15=100
1906—1915	$ 3,150,709	100	$ 2,053,841,000	100
1916—1925	7,031,071	223	5,140,247,300	250
1926—1935	7,610,583	242	4,294,000,000	209
1936—1945	17,272,641	548	6,394,960,000	311
1946—1951	25,061,505	792	10,817,000,000	526
1906—1951	$ 12,027,302	381	$ 5,740,001,000	277

Minerals Exploration Administration has cooperated effectively with the mining industry of North Carolina in making possible the production of certain strategic minerals—especially mica. Robert A. Laurence, executive officer of DMEA for the region embracing North Carolina, submitted the following summary of the work done in North Carolina through December 31, 1953:

Commodity	*Number of Contracts*	*Value of Contracts*	*Government Participation*	*Disbursements N. C. Projects*
Mica	104	$ 571,366.00	$ 514,229.40	$ 400,320.58
Nickel	1	15,392.00	13,852.80	10,012.50
Steatite	1	32,519.00	29,267.10	11,662.32
Beryl, tin, columbium	1	30,500.00	27,450.00	
TOTALS	107	$ 639,777.00	$ 584,799.30	$ 421,995.40

MAJOR INDUSTRIAL DEVELOPMENTS

During the period under review, there were several events of particular significance which showed a marked effect on the mineral industry in North Carolina. Some of the important developments are:

1. Discovery of commercial deposits of tungsten in Vance County in 1942 and their development into one of North Carolina's most valuable mineral resources, the annual production of concentrates exceeding 2,000 tons in 1953.
2. Acquisition by Foote Mineral Company of Solvay Process Company's idle flotation plant and spodumene properties near Kings Mountain in 1950 and the subsequent large-scale production of spodumene concentrates.
3. A two-hundred-million-dollar secondary road improvement program carried out between 1949 and 1952, which resulted in a large increase in the production of stone, sand, and gravel.
4. The drilling of 20 oil and gas exploratory wells in Eastern North Carolina between 1945 and 1953, one of which proved the existence of nearly 10,000 feet of sediments at Cape Hatteras.
5. Erection of a sintering plant for the production of lightweight concrete aggregate near Salisbury in 1949 and the erection of a plant to produce bloated slate aggregate near Albemarle in 1953.
6. Revival of the sheet-mica industry in 1950, following the establishment of a government subsidized exploration and development program supervised by the Defense Minerals Exploration Administration and a subsidized price schedule for mica and other strategic minerals.
7. Construction of a mica-purchasing depot at Spruce Pine by General Services Administration of the United States Government.
8. The intensive survey made in 1950 by the State of North Carolina to find deposits of high-calcium limestones and marls suitable for the manufacture of Portland cement, proving the deposits, and the later acquisition of much of the property by Volunteer Portland Cement Company of Knoxville, Tennessee.
9. Construction of two feldspar flotation plants, one in 1948 and the other in 1950. United Feldspar and Minerals Company, one of the oldest feldspar companies in the state, ceased production after its Minpro

Plant burned. The company and its subsidiary, Carolina Pyrophyllite Company, were taken over b American Encaustic Tile Company. Consolidated Feldspar Corporation was acquired by Internationa Minerals and Chemical Corporation.

10. Extensive exploratory programs were carried out in Eastern North Carolina for ilmenite and othe heavy minerals.
11. A revival of interest in Southern Appalachian sulphide deposits and widespread investigations carried out in North Carolina.
12. Reopening of the Carolina Coal Mine near Sanford in 1948 and its later closing.

An event of interest both to the mining industry and the citizens of North Carolina in general was the allocation of $75,000 by the State of North Carolina in 1953 for the erection of a mineral museum at Gillespi Gap, in Mitchell County, adjacent to the Blue Ridge Parkway. The museum is to be administered by th National Park Service of the United States Department of the Interior and will display only North Carolin minerals and rocks. Dedication of the museum is scheduled for June 1955.

MINERAL RESEARCH

Research on preparation and utilization of the mineral resources of North Carolina was carried out b many industrial firms and state and federal agencies. One of the developments most important to the mineral producers was in 1945, when the State of North Carolina and the Tennessee Valley Authority establishe by cooperative agreement a minerals research laboratory at Asheville. The laboratory was set up to aid i the development of the area's mineral resources by working directly with mineral producers on mining an ore-treatment problems and to conduct basic research on beneficiation of low-grade ores to determine whether or not they have commercial possibilities. From the date of its opening, the laboratory has rendered invaluable aid to the mining industry of the state. Located at 180 Coxe Avenue, Asheville, this unit was administered by North Carolina through the head of the Department of Geology of North Carolina State College an by the Tennessee Valley Authority through its Regional Minerals Section of the Commerce Department. I was operated in cooperation with the Department of Conservation and Development.

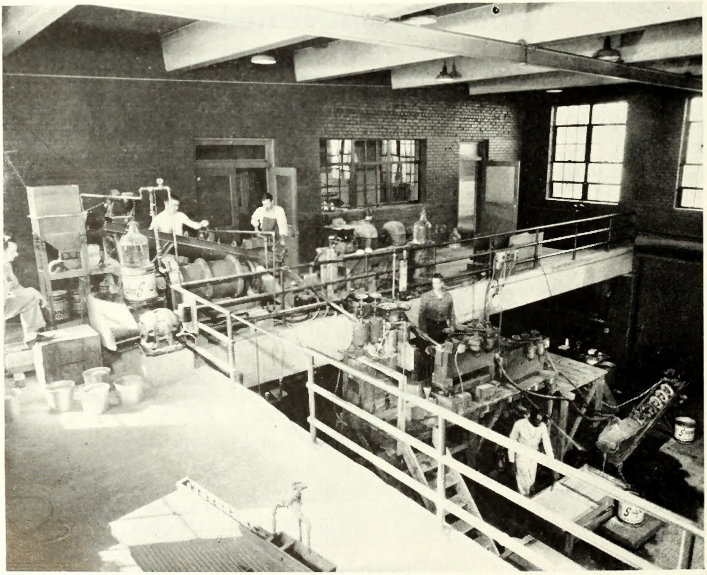

FIG. 3. PILOT PLANT OPERATION, N. C. STATE COLLEGE MINERALS RESEARCH LABORATORY, ASHEVILLE

Among the outstanding contributions made by this laboratory are:

1. Working out froth flotation process and aiding in the design of the plant of Feldspar Flotation Corporation at Spruce Pine and the later refinement of the process.
2. Research on the use of the Humphrey Spiral in the recovery of flake mica, which resulted in the erection of two recovery plants based on this process and the installation of spirals and other equipment in several plants already in existence.
3. Development of a continuous wet-grinding process for mica and the installation of equipment for that purpose at the plant of King Mountain Mica Company.
4. Research on improvement of the quality of low-grade talc, thus increasing greatly the usable talc reserves in the Murphy area.
5. Development of a satisfactory process for the flotation of spodumene, which was used by Foote Mineral Company at its Kings Mountain plant.
6. Research on concentration of andalusite and other high-alumina minerals associated with pyrophyllite
7. Concentration tests on sillimanite ores in North Carolina.
8. Furnishing technical assistance to many small producers who could not afford the high cost of consultants.

In 1950, the Tennessee Valley Authority announced its plans to gradually withdraw financial assistance from the laboratory over a period which terminated on July 1, 1955. The State of North Carolina plans to continue the operation of the laboratory after federal funds have been withdrawn.

Research on the utilization of talc, clays, pyrophyllite, cement raw materials, and other mineral resources was carried out by the Department of Engineering Research, North Carolina State College, Raleigh. Private interests improved the methods of grinding and screening mica, carried out testwork on the production of lightweight aggregate, and made various improvements in equipment, processes, and reagents.

GEOLOGIC INVESTIGATIONS

Since 1945, geologic investigations have been made throughout most areas of the state. Participating in the work were various mining companies and other private interests, the Division of Mineral Resources of the North Carolina Department of Conservation and Development, Tennessee Valley Authority, United States Geological Survey, and United States Bureau of Mines. Many of the studies were conducted as cooperative projects by the various agencies, others were done independently. Work by private industry often is confidential, and results are not always published. Results of studies by state and federal agencies are available usually as public records.

Following World War II, private mineral interests conducted rather extensive studies on feldspar, mica, sulphide minerals, titanium, tungsten, coal, pyrophyllite, kyanite, spodumene, monazite, clay, and limestone resources. Some of the investigations were followed by exploratory drilling and sampling which resulted in commercial development of several deposits. Geologic aspects of certain phases of this work have been published in technical journals.

Formal geologic investigations are carried out by the Division of Mineral Resources of the Department of Conservation and Development both as independent projects and in cooperation with other agencies. In the cooperative projects, the Division of Mineral Resources shares in the expense of the work, and the participating agency furnishes personnel, equipment, and funds. Most of this work relates to mineral resources. Studies carried out by the division separately and in cooperation with the Tennessee Valley Authority and the United States Geological Survey resulted in the publication of twenty-seven mineral-resource reports by the Department of Conservation and Development and numerous reports by the cooperating agencies. Included are those describing the geology and occurrence of feldspar, mica, talc, vermiculite, limestone and marl, halloysite, silica, sillimanite, clay, high-alumina minerals, and ground water. Detailed investigations were carried out in the eastern part of the state in an effort to locate cement raw materials. This was a cooperaive project, sponsored by the North Carolina Department of Conservation and Development, the North Carolina State Highway and Public Works Commission, and the North Carolina Department of Agriculture.

Between 1941 and 1951, the Regional Minerals Section of the Commerce Department, Tennessee Valley Auhority, cooperating with the North Carolina Department of Conservation and Development, was actively engaged in mineral investigations throughout Western North Carolina. Among the outstanding studies resulting were those on olivine, vermiculite, chromite, kaolin, talc, halloysite, sillimanite, feldspar, copper, mica, ilmenite, and barite. Detailed geologic mapping was carried out in the Hot Springs area of Madison County. Reports describing many of these projects were published by the Department of Conservation and Development. Charles E. Hunter, geologist with the Tennessee Valley Authority, deserves special mention for his work on North Carolina minerals. He was directly or indirectly responsible for many of the mineral-resource investigations. As of June 30, 1951, Tennessee Valley authority discontinued its Regional Mineral Section, thus bringing to a close its participation in mineral-resource investigation in North Carolina.

The United States Geological Survey conducted many important studies during the period from 1946 through 1953. As part of its cooperative agreement with the Division of Mineral Resources of the North Carolina Department of Conservation and Development, geologists of the United States Geological Survey mapped in detail the geology of the Spruce Pine district of Avery, Mitchell, and Yancey Counties and the Hamme tungsten district in Vance County and carried out several important mineral studies. Mapping in the Spruce Pine district began in 1941 and was completed in October 1953. A progress report on a part of the work was published as Bulletin 65 of the Department of Conservation and Development. Two unpublished reports, covering portions of the district, are on open file in the offices of the Division of Mineral Resources of the Department of Conservation and Development. Maps and a report on the entire project are being prepared for publication by the geological survey. Mapping in the Hamme tungsten district was conducted from 1950 to 1954, and a report covering the work is being prepared. During 1947 and 1948, geological investigations were made in the Bryson City feldspar district of Swain County, and a report was published as Bulletin 62 of the Department of Conservation and Development. Various investigations were made on pegmatite minerals, including mica, feldspar, and beryl.

Among the important geologic contributions were those by the Ground Water Branch of the United States Geological Survey. In its cooperative program with the North Carolina Department of Conservation and Development, ground-water geologists made detailed studies of ground-water conditions and prepared reconnaissance maps of large districts in the Piedmont region of the state. Results of these studies, published by the Department of Conservation and Development, describe the geology and ground-water resources of the Halifax, Greensboro, Charlotte, Statesville, and Elizabeth City areas.

In addition to cooperative projects, the United States Geological Survey conducted several major studies independently. From 1946 until 1953, geologists of the survey mapped the geology of the Great Smoky Mountain National Park in Western North Carolina and Eastern Tennessee. The geology in and adjacent to the Deep River Coal Field was mapped during 1947 and 1948, and results were published as two preliminary maps, entitled, "Geology of the Deep River Coal Field, Chatham, Lee, and Moore Counties, North Carolina." A report on the structure of the area is on open file in the offices of the Division of Mineral Resources of the Department of Conservation and Development. Between 1948 and 1953, the Shelby quadrangle was mapped in detail, and a report on this work is being prepared for publication. During 1950-1952, investigations were made of the kyanite and sillimanite resources in the Piedmont region of the state. Other projects included studies of the age and distribution of granites and the occurrence of monazite.

The United States Bureau of Mines was active in mineral investigations in North Carolina during and following World War II. Several projects begun during the war were not completed until after 1946. Between 1944 and 1947, iron-ore deposits in the Cranberry area of Avery County were surveyed and core-drilled. Several holes were drilled in the Deep River Coal Field at intervals between 1944 and 1948, and various tests were run on samples. During 1946, exploratory holes were drilled at the molybdenum prospect in Halifax County and at the Cline copper and tungsten mine in Cabarrus County. Between 1948 and 1950, a prospecting and exploratory program was conducted on the Furniss Mine and adjacent properties in Cabarrus County. Spodumene resources were studied also. An intensive drilling and sampling program was carried out from 1951 through 1952 on the monazite deposits in the central Piedmont region, and a concentration laboratory was set up at Shelby. In 1953, the Raleigh Station of the United States Bureau of Mines was restricted to rare-earth mineral studies. As a result of airborne surveys to determine areas of highest radioactivity in the eastern part of the state, the Bureau of Mines ground-checked the more promising localities.

GEOLOGY OF NORTH CAROLINA

North Carolina is 503 miles in length and has an average width of 150 miles. Its total area is 52,712 square miles, of which 49,142 square miles are land and 3,570 square miles are water. Extending from the Atlantic Ocean to the crest of the Great Smoky Mountains, the state has a wide range of topographic and geologic features.

The many varieties of rocks and minerals which characterize its mineral resources reflect the somewhat diverse geologic conditions in North Carolina. Approximately three-fifths of the state is underlain by crystal-ine rocks, chiefly granites and diorites, gneisses, schists, slates, volcanic rocks, and quartzites, and about two-fifths, by unconsolidated sands, gravels, clays, silts, shell limestone and marls. The general distribution and relative ages of the major geologic units are shown on the accompanying geologic map.

North Carolina lies across three major topographic and geologic provinces, namely, the Coastal Plain, Piedmont Plateau, and Appalachian Mountains. The rocks and minerals and their relationships within each province are quite distinctive.

The Coastal Plain is a broad, gently sloping area, occupying about 21,000 square miles or nearly two-fifths of the total area of the state. It extends eastward from the Fall Zone for approximately 150 miles to the Atlantic Ocean and occupies wholly or in part 42 of the state's 100 counties. Materials which cover most of he surface are sands and sandy clays of Pleistocene age. They range in thickness from about 3 to more than 20 feet and accur as a series of broad, relatively flat terraces which dip gently toward the east. Underlying hese terrace materials are formations composed of sands, clays, marls, and shell limestones, which range rom Cretaceous to Pliocene in age. They form a wedge-shaped block of sediments which thicken from a ew feet near their western extremity to nearly 10,000 feet at Cape Hatteras. These sediments lie directly upon crystalline rocks, and subsurface structures appear relatively simple in most areas. The principal mineral resources of the Coastal Plain are shell limestones and marls, sands, gravels, ilmenite, clays, peat, phosphate, and greensands. It is the only region in the state which has possibilities for the occurrence of oil r gas in commercial quantities.

Lying between the Coastal Plain on the east and the Appalachian Mountains on the west is the Piedmont Plateau, a broad, rolling region covering approximately 22,000 square miles in Central North Carolina. It ises from an approximate elevation of 300 feet near its eastern border to more than 1,500 feet on the west nd has an average elevation of about 1,000 feet. Its topography is gently rolling in most areas but is broken ccasionally by steep-sided hills and ridges.

The Piedmont Plateau is underlain by a wide variety of rocks of metamorphic, igneous, and sedimentary rigins. Ages range from pre-Cambrian to Triassic. The western third of the region consists of mica and ornblende gneisses and schists and small bodies of granitoid rocks, principally granites and quartz-mon-onites. Pegmatites are common in some areas but are most common in parts of Cleveland, Rutherford, Gaston, Lincoln, and Catawba Counties. Small, intermittent occurrences of quartzites, limestones, and asso-iated rocks extend from near Kings Mountain, Cleveland County, to Danbury in Stokes County. Lying to he east of the large gneiss and schist units is a broad belt of igneous rocks, chiefly of granitic and dioritic ompositions, which extends from the South Carolina state line northeastward through Charlotte, Salisbury, nd Greensboro to near Roxboro. A second belt crops out from near Raleigh, in Wake County, northeastward hrough Franklin and Warren Counties to the Virginia state line. Smaller bodies are scattered throughout much of the Piedmont. In contact with the central or main belt of granitoid rocks on the east are rocks of he Volcanic-Slate series, a group of interbedded flows, tuffs, breccias, phyllites, and slates. These rocks ccupy a broad zone, extending northeastward across the east-central Piedmont region, and a smaller area long the eastern border. The volcano-sedimentary rock series is slightly to moderately metamorphosed and as been intruded by granites and diorites. Two important areas of Triassic sandstones and shales are pres-nt. One lies along the Dan River basin in parts of Forsyth, Stokes, and Rockingham Counties. The other xtends southwestward from central Granville County to the South Carolina state line and covers consider-ble areas in Granville, Durham, Orange, Chatham, Moore, Lee, Montgomery, Richmond, and Anson Counties. Mineral resources of the Piedmont Plateau include dimension granite, flagstone, construction stone, sand and ravel, clays and shales, kaolins, mica, spodumene, pyrophyllite, andalusite, monazite, tungsten, barite, man-anese, kyanite, sillimanite, soapstone, and lesser amounts of copper, tin, lead, gold, columbite-tantalite, and eryl.

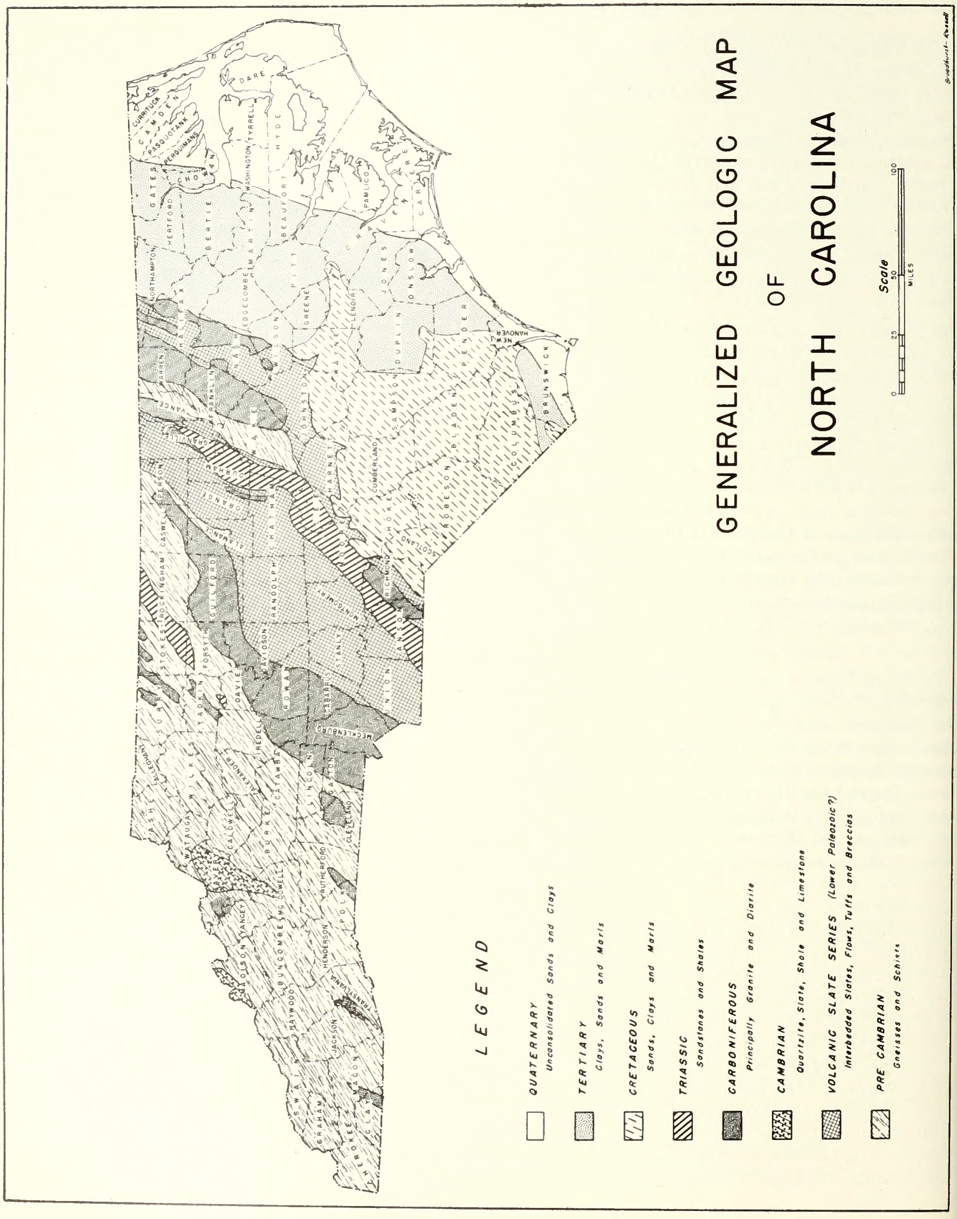

FIGURE 4. GENERALIZED MAP OF NORTH CAROLINA

The Appalachian Mountain region of North Carolina extends from the Blue Ridge Mountains on the east to he Great Smoky ranges on the west. The area occupies nearly 10,000 square miles of mountainous territory, which averages about 2,700 feet in elevation but which contains many ridges more than 5,000 feet high. Mt. Mitchell, the highest mountain in Eastern North America, has an elevation of 6,684 feet and is located in he north-central part of the area.

Most of the rocks in the Mountain region consist of highly folded mica and hornblende gneisses and schists which have been intruded by large masses of granitic and ultrabasic rocks. Pegmatites are common in the area, being most extensive in the Spruce Pine and Franklin-Sylva districts. Slates, arkosic quartzites, and iltstones of the Ocoee series are widespread in parts of Cherokee, Graham, Swain, Haywood, and Madison Counties and are found to a lesser extent in areas to the east. The Murphy marble and its accompanying talc deposits extend from southwestern Swain County through central Cherokee County. The Brevard schist, which extends from eastern Transylvania County to east-central Buncombe County, contains important lenses of imestone. Cambrian limestones and quartzites are present in parts of McDowell, Mitchell, Avery, and Waauga Counties, and near Hot Springs, Madison County. Among the important mineral resources in the Mountain region are feldspar, mica, kaolin, vermiculite, olivine, limestone and marble, talc, asbestos, chromite, sand and gravel, iron, ilmenite, copper, and rutile. Small amounts of radioactive and other rare-earth minerals have been recognized in widespread areas.

MINERAL RESOURCES

Approximately 300 varieties of rocks and minerals have been identified in North Carolina. This is reportd to be the greatest number found in any state. Many are quite rare and are of interest only as collectors' tems; others are widespread in occurrence but are not concentrated in amounts to be of economic importance. Between forty and fifty have been produced commercially. The following sections describe in general the more important mineral resources of the state. Individual minerals or rocks are described alphabetically under four major classifications, namely, metallic minerals, nonmetallic minerals, rare-earth and other minrals, and mineral fuels.

METALLIC MINERALS

CHROMITE

Chromite is the name applied to a chrome-bearing group of minerals which form an isomorphous series having the general formula $(Mg,Fe)O \cdot (Cr,Al,Fe)_2O_3$. Within this group there is such a wide range in hemical composition that the Cr_2O_3 content of a mineral designated as chromite could vary from less than 0 percent to more than 60 percent.. Most commercial grades of chromite range from about 34 percent to 48 percent Cr_2O_3.

Chromite, the principal source of chromium, is a highly strategic mineral. It is used in the manufacture f ferro-chromium, stainless steel, chromium metal, varoius alloys, and refractory bricks and cements. Chromic salts are used in electroplating, dyeing, tanning, pickling nonferrous metals, and various pigments. Of he total domestic consumption, from 45 percent to 50 percent is used for metallurgical purposes, approxmately 37 percent for refractory products, and about 15 percent for chemical uses.

Specifications for concentrated ores vary with their use but are based usually on the Cr_2O_3 content, the atio of chrome to iron, and presence of various impurities. Chrome ores purchased by the United States Government's General Services Administration must meet the following requirements: Chromic Oxide (Cr_2O_3), minimum 42 percent; silica, maximum 10 percent; and chrome-iron ratio, minimum 2:1. Specications for most metallurgical ores are based on a 48 percent Cr_2O_3 content and a 3 to 1 chrome-iron ratio. Most refractory grade ores carry about 33 percent Cr_2O_3, 17 percent MgO, and 10 percent iron, with silica s low as 2 percent. Chemical grade ores usually contain a minimum of 44 percent Cr_2O_3. Many have a hrome-to-iron ratio of about 1.6 to 1.

Over one million tons of chromite are consumed annually in the United States, most of this amount being mported from the Union of South Africa, Turkey, the Philippines, and Southern Rhodesia. Domestic production is less than 0.5 percent of national requirements. The more important chromite-producing areas in

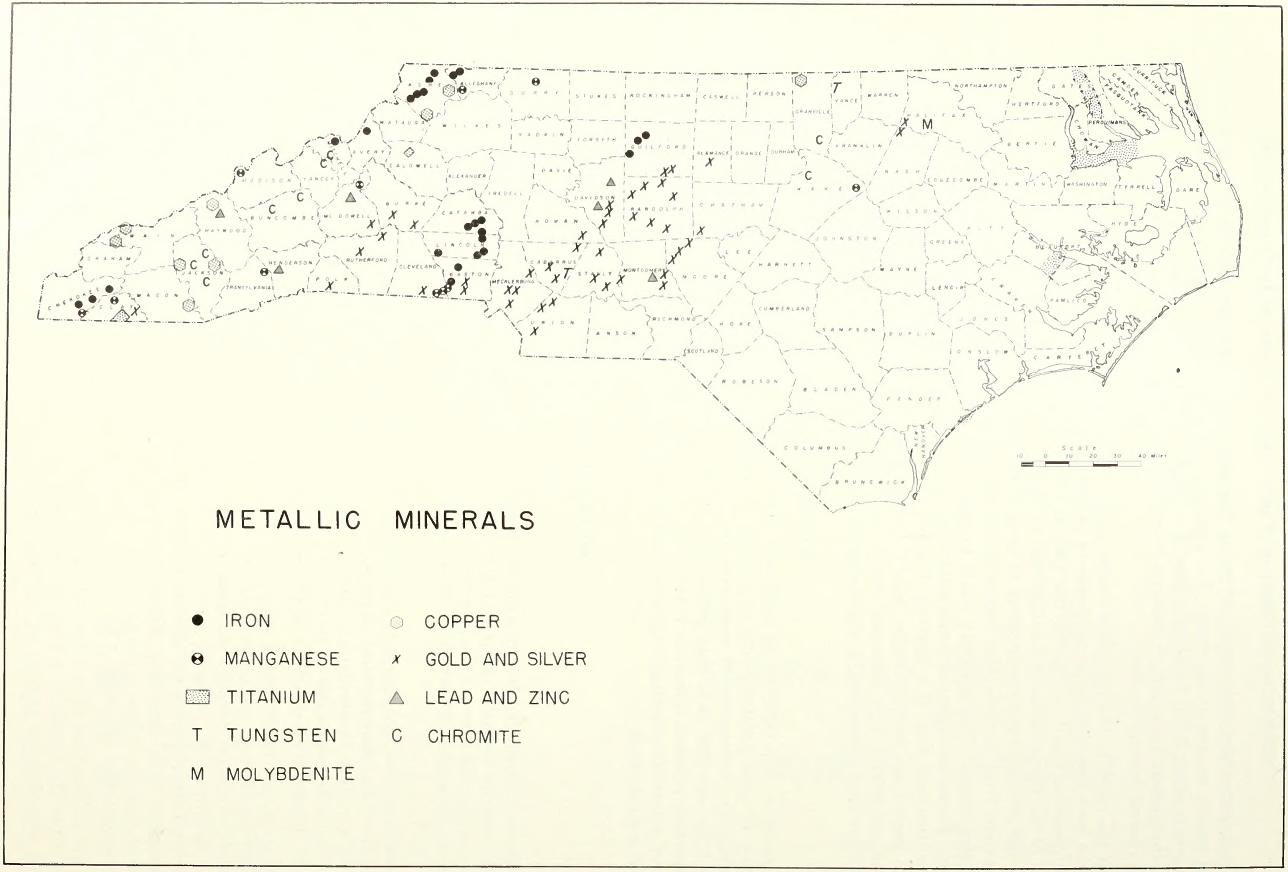

FIGURE 5. METALLIC MINERALS

he United States are in Montana, Oregon, and California. Since 1870, it has been known that the mineral ccurs in North Carolina, and sporadic attempts have been made to mine it. Such attempts, however, have een only partially successful, and the total production is estimated at less than a thousand tons.

In North Carolina, chromite occurs as disseminated crystals and small, massive lenses in ultrabasic rocks, rincipally the peridotites. Most of the known deposits are too small or of too low grade to be mined profit-bly. Two of the more promising deposits are at Day Book, Yancey County, and Democrat, Buncombe ounty, the Democrat deposit having been worked on a limited scale during both world wars. Other occur-ences include those at Webster, Jackson County; Leicester, Buncombe County; Holcombe Branch, Madison ounty; Price Creek, Yancey County; Addie, Jackson County; Corundum Hill, Ellijay, and Norton, Macon ounty; Plyler property near Statesville, Iredell County; and the Adam Mountain-Wilton area of Wake and ranville Counties. Analyses of samples from some of the deposits are:

Analyses of North Carolina Chromite

ocation	Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	Mgo	Cr:Fe
ay Book	44.20	20.05	0.30	21.30	14.48	2.14:1
emocrat	55.52	28.50	0.80	----	----	1.9:1
Vebster	22.61	18.91	16.90	16.70	24.63	1.16:1
ark Ridge	39.66	14.18	7.20	26.80	12.34	2.7:1
ddie	29.46	19.89	11.40	24.00	15.74	1.45:1

During the period 1945-1954, no chromite was produced in North Carolina. Activity was limited primarily prospecting in the Adam Mountain-Wilton area of northern Wake and southern Granville Counties. Here, hromite occurs in a series of serpentinized and steatitized peridotite bodies, which form an irregular belt pproximately 3 miles wide and 15 miles long and extend from near Adam Mountain, in northern Wake ounty, to a short distance northeast of Wilton, in Granville County. The chromite is of a low grade and ccurs disseminated throughout the basic rocks and as massive stringers within the formations. Two pros-ect holes were drilled between 1949 and 1952. One of these was in the southern end of the belt; the other, the northern end. Samples of the chromite averaged less than 30 percent Cr_2O_3 in most cases.

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COPPER

Of the nonferrous metals, none is more essential to modern industry than copper. Its high conductivity akes it of prime importance for electrical transmission, and this is its principal use. It is also used widely s an alloy metal, chiefly in brasses (copper-zinc alloys) and bronzes (copper-tin-zinc allows). Copper is so alloyed with aluminum, steel, arsenic, beryllium, chromium, magnesium, manganese, cobalt, and other etals.

Ores of copper are divided into four groups according to mineralogical occurrence: native metal, sulphide, xide, and complex. Of these, sulphides are the most important. The complex ores are those in which pper occurs with other metallic minerals, such as lead, zinc, gold, and silver. Approximately 165 copper inerals have been identified; of these, 16 are of the greatest commercial importance. The principal cop- er-producing states are Utah, Montana, Arizona, and Michigan.

In North Carolina, copper minerals are widespread in the crystalline rocks of the Piedmont and Mountain gions. Most of the economically important copper minerals have been found in the state, but the more ommon are chalcopyrite, bornite, and lesser amounts of chalcocite, malachite, azurite, and cuprite. Native opper has been found sparingly at a few localities. The more important deposits occur as fissure veins and e usually of somewhat complex hydrothermal origins.

Copper has been produced in North Carolina for more than a hundred years, but the volume has been mparatively small. The greatest period of activity was between 1850 and 1930. During recent years, the

Fontana Mine in Swain County has been the only important producer, although a small production is recorded from the Adams Mine in Swain County and the Dixie Queen in Cabarrus County between 1943 and 1944. No copper has been produced in North Carolina since 1944. During and following World War II, considerable interest in the sulphide deposits of the state developed, and several major exploratory programs were initiated. As a part of its strategic minerals program, the United States Bureau of Mines investigated many of the copper deposits and core-drilled several of the more promising. During 1942, the Tennessee Valley Authority, cooperating with the North Carolina Department of Conservation and Development, studied the copper deposits in Western North Carolina, and results of this work are on file in the offices of the Division of Mineral Resources. Since 1945, several major mining companies have been conducting detailed studies of the state's sulphide resources.

Geographically and geologically, the North Carolina deposits appear in three principal zones: Western, Central, and Eastern. The Western Zone occupies a considerable portion of the mountainous area of the state, especially parts of Ashe, Watauga, Alleghany, Jackson, Clay, Macon, and Swain Counties. Most of the rocks are gneisses and schists which have been intruded by granites, pegmatites, quartz veins, and basic rocks. The Central Zone embraces that area in the central Piedmont region which is underlain by granitoid rocks of the Main Igneous Belt and includes parts of Mecklenburg, western Cabarrus, Rowan, and Guilford Counties. The Eastern Zone is essentially that part of the central and eastern Piedmont region underlain by rocks of the Volcanic-Slate series, the more important areas being in Person, Granville, Cabarrus, Rowan, and Davidson Counties.

The following descriptions of these zones have been condensed from the original manuscript of Economic Paper 65 of the North Carolina Department of Conservation and Development and certain unpublished reports in the files of the Division of Mineral Resources:

Western Zone: The Western Zone is the most important and the only one from which there has been any important production recently. The best deposits occur as fissure veins in schists and gneisses of the crystalline complex. Some appear associated with basic intrusives. The veins are of complex hydrothermal origin, although there are areas where mineralized zones appear in the schistose country rock.

The predominant ore mineral is chalcopyrite, although other sulphides, such as chalcocite, bornite, and pyrrhotite, were common in the secondary ores which have now been largely removed at most mines. They also contained minor amounts of cuprite, malachite, azurite, and chrysocolla.

Among the better known copper mines in the Western Zone are: Ore Knob, Ashe County; Cullowhee, Jackson County; Fontana, Swain County; Adams (Hazel Creek), Swain County; Elk Knob, Ashe and Watauga Counties; and Savannah, Jackson County. Other occurrences include the Peachbottom Mine, Ashe County; Moody Mine, Jackson County; Kitchens Knob, Clay County; Wilkins Knob, Haywood County; Allison Prospect, Jackson County; and McGuire Mine, Macon County. The more important of these are the Ore Knob, Elk Knob, Cullowhee, Fontana, and Adams Mines.

ORE KNOB

This mine is in the eastern part of Ashe County, 8.2 miles east of Jefferson and 1 mile north of N. C. Highway 88. It is a fissure-type vein and occurs in a biotite gneiss formation. The deposit is believed to range from 8 to 16 feet wide, averaging approximately 10 feet in thickness. Results of core-drilling indicate a vein structure some 200 feet along its minor axis and 1,500 feet along its major axis. It plunges to the southwest at from 15° to 20°. Ore minerals consist of chalcopyrite, pyrrhotite, pyrite, and minor quantities of sphalerite. Gangue includes biotite, magnetite, albite, calcite, and various silicate minerals. Contacts between the ore body and wallrock are quite sharp.

The Ore Knob Mine was opened first in 1855 to 1866 and again systematically exploited between 1873 and 1883. A total of 11 shafts, ranging in depth from 60 feet to more than 400 feet, were sunk during this period. It is reported that more than 200,000 tons of ore were mined, from which were produced nearly 12,500 tons of copper. The mine was reopened briefly in 1896, and several carloads of hand-cobbed slag were shipped. In 1913, one carload of slag was sold. Between 1917 and 1918, the mine was dewatered, and several carloads of ore were produced; in 1927, one shaft was reopened, but little ore was produced. During 19 and 1943, the United States Bureau of Mines drilled 20 diamond-drill holes along the strike of the vein

During 1953 and 1954, an extensive core-drilling program was conducted at Ore Knob by Nipissing Mines, Limited, and more than a million tons of ore were blocked out below and toward the southwest from the old workings. This company plans to sink a shaft on the ore early in 1955.

ELK KNOB

Elk Knob lies along the county line between Ashe and Watauga and contains several occurrences of sulphide minerals. During 1940, the Carolina Corporation of Charlotte drilled 7 holes in Ashe County, totaling about 1,100 feet. This work was on a vein from 5 to 6 feet wide and nearly vertical. Sulphides present include pyrite, pyrrhotite, chalcopyrite, and minor amounts of sphalerite. Later, a prospect was opened along the northern slope of Elk Knob in Watauga County, about a mile from Tamarack. At this locality, mineralization of hornblende country rock consists of pyrite, pyrrhotite, and chalcopyrite. The sulphides make up about three-fourths of the veins where it is well defined. As exposed, the body is from 4 to 6 feet wide and about 100 feet long. Samples are said to average approximately 9.8 percent copper. Additional exploratory work was carried out about 1952, and the property was investigated by several mining companies during 1953.

CULLOWHEE MINE

The Cullowhee Mine is about 9 miles southeast of Sylva, Jackson County. This mine was worked between 1900 and 1910, during which time a small body of oxidized and secondarily enriched ore was mined. A smelter for treating the sulphide ore was operated at the mine. Late in 1929, Tennessee Copper Company reopened the mine and operated it until July 1930. It is reported that production amounted to approximately 4,500 tons of sulphide ore, averaging 4 percent copper. Development work consisted of a main shaft 177 feet deep, with various drifts, cross cuts, and adits. The ore zone averages from 3 to 6 feet wide but ranges from a few inches to as much as 18 feet.

FONTANA MINE

Its history of production shows the Fontana Mine to be the most important in the Western Zone. It is located in southwestern Swain County, a few miles north of the village of Fontana. The ore body is a large lens, which conforms to the regional structure of the enclosing schists and dips about 40° southwest. Ore minerals include pyrrhotite, chalcopyrite, pyrite, sphalerite, and galena. The ore body has been well developed, and it is reported that ore extraction was through a 2600-foot shaft.

The North Carolina Exploration Company began production at the Fontana Mine in 1926 and, until January 31, 1944, shipped crude ore to Tennessee Copper Company's smelter at Copperhill, Tennessee. The cessation of operation was brought about by the construction of Fontana Dam on the Little Tennessee River. Water level of the lake was considered too close to the shaft, and the property was abandoned. Production figures for this mine are not available for publication.

ADAMS (HAZEL CREEK) COPPER MINE

This mine is in the southwestern part of Swain County, on the east side of Gold Mine Branch, a tributary of Hazel Creek, and is 2.3 miles north of the village of Proctor. The deposit is of the primary sulphide type occurring in and along a fault zone in chlorite-mica schist. Development work has shown that there are three principal lens-type bodies, which are roughly parallel and overlap at several places. Chalcopyrite is the most abundant sulphide mineral and is asosciated with pyrrhotite, sphalerite, pyrite, quartz, chlorite, calcite, and smaller amounts of other minerals. Diamond-drill holes indicate that the ore body has a maximum width of about 11 feet, averaging about 6 feet.

Prior to 1943, most of the work at this property was of an exploratory nature, and probably less than five carloads of ore were shipped. Between 1900 and 1910, the gossan outcrop was prospected by crosscuts and small open cuts. Shortly after 1920, the mine was developed by 10 adits, 3 shafts from the adits, and 3 shafts from the surface. Thirty-six drill holes were put down by the Ducktown Chemical and Iron Company during 1929 and 1930 but these failed to block out a commercial ore body. The North Carolina Mining Company of Webster and Proctor started exploratory work in 1942 and made shipments of ore to United

States Metals Refining Company's smelter at Carteret, New Jersey, from April until December 1943. Thi ore averaged approximately 10 percent copper, 5 percent zinc, 0.25 percent lead, and 0.01 ounces of gol and 1.3 ounces of silver per ton. Between January and October 1944, the mine was operated on a small scale A small flotation mill was operated at the mine when the property was being cleaned up prior to being abandoned. A report and maps of the Adams Mine, prepared by the Tennessee Valley Authority and the Nort Carolina Department of Conservation and Development, are on file in the offices of the Division of Minera Resources.

Central Zone: In the central Piedmont area of acid, crystalline rocks there is a group of sulphide deposit which was first worked for gold and later for copper in the middle of the nineteenth century. The ore minerals were predominantly pyrite and chalcopyrite—the former sometimes auriferous. All of these properties have long been abandoned. The better known of them are the North Carolina or Fentress, Gardne Hill, Hodges, North State, Twin, and Jacks Hill properties in Guilford County and the Ray, Ferris, McGinn Kerns, Cathey, and McLeary properties of Mecklenburg County. During World War I, the Gardner Hil property was prospected, and several of the mines were investigated during World War II. In 1943, a carload of 3-percent copper ore, containing some gold and silver, was shipped from the Dixie Queen Mine i Cabarrus. During 1952 and 1953, the Central Zone was being studied by industrial geologists.

Eastern Zone: The Eastern Zone is separated from the Central Zone by geologic rather than geographi conditions. While the Central Zone is restricted largely to the belt of granitoid rocks which comprise the Main Igneous Belt, the Eastern Zone is restricted for the most part to deposits occurring in rocks of the Volcanic-Slate series, a large belt of rocks which contacts the granitoid rocks on the west. The Easter Zone is of importance principally near its extremities. In the north is the Virgilina district, occupying parts of Granville and Person Counties, and to the south are the related Gold Hill and Cid districts in Cabarrus Rowan, Stanly, and Davidson Counties. Between the two principal areas is a series of occurrences in Chatham County and adjacent areas, which is of interest but from which there has been very little production.

VIRGILINA DISTRICT

The Virgilina district consists of a relatively narrow northeastward trending area which lies along the state line between North Carolina and Virginia. Approximately half of the productive area is in each state the North Carolina portion comprising an area about 22 miles long and 18 miles wide in northern Granville and Person Counties. The ore deposits occur in well defined veins in which quartz is the predominant mineral. The veins lie along zones of fracture, which trend toward the northeast at from 10° to 30°. The chie ore minerals are chalcocite, bornite, chalcopyrite, and pyrite, with lesser amounts of native copper, azurite malachite, cuprite, chrysocolla, argentite, silver, and gold. In the shoots which have been opened up, the ore is reported to average from 2.5 percent to 3 percent copper. Few of the veins are more than 10 feet wide the average width being about 3 feet. Practically all of the mines developed in the North Carolina portion of the district lie along the same strike. A secondary axis of mineralization appears about three-fourths of a mile northwest of the main axis and runs parallel with it.

The principal mines of the Virgilina district in North Carolina are:

1. Blue Wing, about 1.5 miles south of Virgilina, having an estimated reserve of 15,000 tons of blocked ore, containing 2 percent copper, 0.8 ounces of silver per ton, and 60 percent silica. It is estimated that more than 50,000 tons of ore have been mined from the Blue Wing.
2. Holloway, about 1.75 miles southwest of the Blue Wing and along the regional strike. From May 1897 to April 1903, more than 400 cars of ore were shipped. The average copper content was probably about 10 percent.
3. Durgy, or Person Consolidated, is about a mile west of the Holloway and has an estimated reserve of 48,000 tons of blocked ore, assaying 2 percent copper, 0.9 ounces of silver per ton, and 70 percent silica with an average vein width of 8 feet.

Various geologic investigations have been made of the Virgilina district. One of the most complete of these was published as Bulletin 26 of the North Carolina Geological and Economic Survey and as Bulletin 14 of the Virginia Geological Survey in 1917. There are several consultants' reports on the various mines.

During World War II, the United States Bureau of Mines carried out geophysical and core-drilling explor-

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atory work in the district; during the period under review, the area was investigated by several companies, especially during 1951 and 1952. In 1953, Nipissing Mines, Limited, began studies in the district.

GOLD HILL DISTRICT

This district occupies parts of Rowan, Cabarrus, and Stanly Counties and consists of an area approximately 8 miles wide and 18 miles long, extending from the Yadkin River southwestward to near Mt. Pleasant. Four mines and numerous propects, locally called mines, represent the workings of the Gold Hill mining district. They are well confined to the western edge of the Volcanic-Slate series and apparently to a zone of shear known as the Gold Hill fault. The more important openings are the Gold Hill Mine, Union Mine, Whitney Mine, and Southern Copper and Mining Company's openings.

The Union Copper Mine, a mile south of the village of Gold Hill and located along the county line between Cabarrus and Rowan, was explored by core-drilling in 1943 by the United States Bureau of Mines; and, in 1946, the Cline Mine, located about 4 miles north of Mount Pleasant in Cabarrus County, was drilled by the same agency. Between 1950 and 1953, several studies were made in the Gold Hill area, and the Randolph shaft was dewatered partially but later allowed to refill. From 1946 through 1953, the United States Bureau of Mines drilled several exploratory holes in various sulphide ore bodies in Cabarrus and Union Counties.

CID DISTRICT

Immediately north of the Gold Hill District is a mineralized area known as the Cid Mining District. It is ocated in southern Davidson County adjacent to the Yadkin River. Among the more important mines in the listrict are the Silver Hill, Silver Valley, Conrad Hill, and Emmons. Ores are complex and are in general imilar to the Gold Hill deposits. Although this area was inspected several times during the period under eview and exploratory drilling done at the Silver Hill Mine, no ore was produced. The Scarlet Copper Mine, near Asheboro, was drilled by the United States Bureau of Mines in 1948.

CHATHAM COUNTY AREA

In southwestern Chatham County and adjacent areas in Moore, Lee, Randolph, and Montgomery Counties, here are several interesting occurrences of copper. Some of the deposits were opened during World War I, but production was limited and the mines were closed after short periods of operation. Among the more mportant of these mines were the Bear Creek Mine, 3 miles southwest of Harpers Cross Roads in southwestern Chatham County, and the Millwright Mine, 2.5 miles southeast of Harpers Cross Roads. A small roduction of copper was reported from the area in 1944.

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GOLD AND SILVER

Gold mining in North Carolina has had a long and checkered history. Although it is not known when the mining for gold was first undertaken, United States Mint returns for the state appear as early as 1793. The first authentic discovery was in 1799, and systematic mining began about 1800. From 1804 until 1823, North Carolina furnished all of the gold produced in the United States and was a leading producer until 1849, when major discoveries were made in California. Since that time, gold has been mined sporadically throughout many parts of the state, but the industry has not been strong and its history is marked by short periods of activity followed by longer ones of dormancy.

Early production was from placer and residual deposits from which fine particles and nuggets were recovered easily. During this period there was a great boom in gold mining; however, the "free gold" deposits were depleted rapidly, leaving only the low-grade, complex sulphide ores. Many attempts have been made to mine and process these ores, but few of the ventures proved to be profitable. A small proportion of silver, commonly about 10 percent, is naturally alloyed with gold in parts of North Carolina, and at some mines it has been recovered profitably. However, most of the silver produced in the state has come from copper and copper-lead-zinc ores.

The gold and silver producing areas of North Carolina are:

1. Eastern Carolina Belt: Franklin, Nash, Warren, and Halifax Counties.
2. Volcanic-Slate Belt: Extending from Person County on the north across the intervening counties to Anson and Union on the south.
3. Carolina Igneous Belt: Paralleling the Volcanic-Slate Belt on the west and varying from 15 to 35 miles in width. It includes parts of Person, Caswell, Alamance, Guilford, Forsyth, Davie, Davidson, Rowan, Iredell, Cabarrus, and Mecklenburg Counties.
4. Kings Mountain Belt: Irregular in shape and extending along the southern half of the Carolina Igneous Belt. It is relatively small and consists of parts of Cleveland, Lincoln, and Gaston Counties.
5. South Mountain Belt: About 300 square miles in Burke, McDowell, and Rutherford Counties.
6. Western Belt: The area west of the Blue Ridge Mountains.

Within these areas are more than 625 mines from which gold production has been recorded. The total production in North Carolina from 1799 through 1953 is 1,164,601 fine ounces, valued at $24,328,298.00. The most important period of production was 1829-1855, when 393,119 fine ounces, representing 33.7 percent of the total production of the state, were recovered. From 1866 until 1917, the average annual production was 4,886 fine ounces; but, from 1917 until 1935, it was only 297 fine ounces. Following a change in price from $20.67 to $35 per ounce during 1933-1935, there was renewed activity in gold mining, and the average annual production in North Carolina from 1935 through 1944 was 1,695 fine ounces. There have been few attempts to mine gold in North Carolina since 1944. In 1949, 13 fine ounces were produced from Rutherford County. Small-scale prospecting was carried out in Rutherford, Rowan, Cabarrus, Montgomery, and Halifax Counties. A small amount of gold-lead concentrates was produced from the House property in Halifax County in 195

No silver has been produced in North Carolina during recent years. The total production of silver in North Carolina (1799-1953) is recorded as 357,223 fine ounces. Of this amount, more than 300,000 ounces were recovered as a byproduct during mining and milling copper and copper-lead-zinc ores, the remainder being recovered during gold mining and processing. Native silver was found in small quantities at the Silver Hill Mine in Davidson County.

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IRON

Iron, the second most abundant of all metals, is the most important industrially. There are four main types of iron available for industrial consumption: steel, cast iron, wrought iron, and iron alloys. Each ty has a myriad of uses. The United States accounts for about 50 percent of the annual world production, most of the domestic ores coming from Minnesota, Michigan, and Alabama.

The principal iron-bearing minerals are magnetite (the magnetic oxide), hematite (the red oxide), limonite (the brown oxide), and siderite (iron carbonate). All of these minerals occur in North Carolina, most of them having been produced commercially. Iron ores are scattered widely throughout the state. Deposits of magnetite occur in Granville, Stokes, Surry, Catawba, Lincoln, Ashe, Avery, and Mitchell Counties. Hematite ores are restricted principally to Granville and Ashe Counties. Limonite deposits are chiefly in Chatham, Gaston, Madison, and Cherokee Counties. Bog ores occur in the Coastal Plain region. Small amounts of siderite have been found at a number of localities, but deposits of commercial significance are unknown.

Iron was manufactured in North Carolina as early as 1729, and by 1850 a small industry based on local ores flourished throughout the state. With the discovery of large deposits of ore in other areas and improvement in transportation, iron became more plentiful, and the small North Carolina furnaces were forced to close. Most of the state's recorded production has been from Avery and Cherokee Counties. Since 1900 approximately 1,400,000 tons of ore have been produced, most of it before 1925. The last recorded production in North Carolina was in 1936, when 57 tons were shipped from the Maltby Mine in Cherokee County.

Although iron ore is common in the state, there are but few localities in which it is present in sufficient quantity or of a quality to be considered of potential value. These are the Big Ore Bank in Lincoln County, the Cranberry area of Avery County, and deposits in Cherokee County. During 1942-1945, these areas were investigated by representatives of the State of North Carolina, the United States Geological Survey, and the United States Bureau of Mines to determine the possibilities of the ores as sources of raw material for the manufacture of sponge iron. (See References.)

Big Ore Bank: A narrow belt of magnetic ore extends in a northeasterly direction from about 3 miles northeast of Iron Station, in Lincoln County, to Anderson Mountain, in Catawba County, a distance of approximately 9 miles. The ores are associated with an elongated belt of metamorphosed sediments, including quartzites, schists, and dolomitic limestones. The greatest concentration of ore is in the vicinity of Big Ore Bank, 6.5 miles east of Lincolnton and about a mile south of N. C. Route 150, where it occurs within an area approximately 0.25 mile wide and 1 mile long. Other openings north and east of the Big Ore Bank are the Brevard, Stonewall, Morgan, Robinson, Morrison, and Beard Mines. Results of magnetic surveys and core drilling carried out during World War II indicate that this belt contains about 300,000 tons of ore which average 28.4 percent iron.

Cranberry Area: This area contains the greatest ore reserves known in the state and has accounted for most of the recorded production. The Cranberry Mine, largest in the area, is located in Avery County, about 1.5 miles southeast of the village of Elk Park and 2.5 miles from the Tennessee State Line. Ore from this locality was mined as early as 1820, although the principal period of production was from 1876 to about 1925. The mine was closed in 1930. From 1882 until 1930, 1,500,418 tons of ore are reported to have been produced. A preliminary estimate, based on 12 core-drill holes and other available information, indicates that the remaining reserves are at least 1,600,000 tons.

Tests by the United States Bureau of Mines on typical samples show that grinding to 65-mesh or finer is necessary to free the magnetite from its gangue, after which concentrates assaying 70.3 percent Fe, 0.035 percent S, 0.002 percent P, and 1.10 percent SiO_2 were obtained by passing the ore through two Crockett Type-K magnetic separators. Ninety-four percent of the magnetic iron and 89 percent of the total iron were recovered. The head samples averaged about 30 percent Fe, and the ratio of concentration was 2.65 to 1.

Cherokee County Area: Iron ore in Cherokee County is limonite, or brown ore. It occurs from Ranger northeastward to Andrews, a distance of about 22 miles. Most of the deposits are along either side of Valley River, which enters the Hiwassee River at Murphy. A few are found in the valley of Peach Tree Creek near Peach Tree, 5 miles east of Murphy. The only deposits which have proved to be of commercial importance are those in the Andrews schist near its contact with the Nottely quartzite. This belt extends from the Fain-Hitchcock Mine, 1 mile southwest of Murphy, northeastward for about 15 miles to the Marvacar Mine, south of Andrews and Valleytown. Ore was mined in the area as early as 1840, but most of the production was during World War I. Between 1917 and 1920, approximately 126,000 tons of brown iron ore were produced in the state, most of which came from Cherokee County. The area has been practically dormant since that time except for a small production in 1936. Probable tonnages below the old workings of the principal mines and in the most important prospects have been estimated at between 250,000 and 500,000 tons.

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LEAD AND ZINC

Lead and zinc are among the metals most important to industry, ranking next to copper as essential nonferrous metals. The major uses of lead are in the preparation of red lead and litharge, in cable coverings, and in storage batteries. Zinc is used in galvanizing, die castings, and brass-making.

The most common mineral form of lead is the sulphide galena (PbS), but it also occurs as cerrusite ($PbCO_3$) and anglesite ($PbSO_4$). Zinc minerals include sphalerite or zincblende (ZnS), smithsonite ($ZnCO_3$), calamine ($Zn_4Si_2O_7(OH)_2H_2O$), zincite (ZnO), and willemite (Zn_2SiO_4). Galena and sphalerite are the principal lead and zinc ore minerals, and they are usually found together.

Lead and zinc minerals are found in small quantities in the crystalline rocks of North Carolina. In most instances they occur in the same ore and are associated with pyrite, chalcopyrite, and other sulphide minerals Most of the ores carry small amounts of gold and silver. The principal localities in which the occurrence o lead and zinc are known are:

Alleghany County: Peachbottom Mine.
Cabarrus County: Rocky River, Allen Furr, McMakin, and Troutman Mines.
Caldwell County: Baker Mine.
Davidson County: Silver Hill, Silver Valley, and Welborn (Smith) Mines.
Gaston County: Kings Mountain and Lawton Mines.
Haywood County: Redmond prospect.
Henderson County: Little Hungary River (Brown) Prospect.
McDowell County: In the Shady dolomite near Linville Caverns.
Montgomery County: Steel, Henderson, and Russell Mines.
Randolph County: Hoover and Boss Mines.
Rowan County: Union and other mines in the Gold Hill district.
Swain County: Hazel Creek (Adams) Mine.
Union County: Lemmonds, Smart, Stewart, Moore, and Long (Cromwell) Mines.
Watauga County: Beech Mountain.
Wilkes County: Flint Knob Mine.

From 1946 to 1953, there was no recorded production of lead or zinc from North Carolina. Most of th activity was confined to exploratory work at the Silver Hill Mine and the Redmond and Hungary Rive (Brown) Prospects.

Silver Hill Mine: This mine, located in Davidson County, 9 miles southeast of Lexington and 4 miles northeast of Southmont, is one of the more famous mines in the state. The ore is complex, consisting principall of galena, sphalerite, pyrite, chalcopyrite, and minor amounts of gold and silver. An average of 200 assay of the ore is, as follows: galena, 21.9 percent; pyrite, 17.1 percent; sphalerite, 59.2 percent; silver and leac 0.025 percent; and chalcopyrite, 1.8 percent. In the upper, weathered part of the ore body, a considerabl amount of native silver was recovered during the early period of mining.

The Silver Hill Mine has been worked intermittently since its discovery in 1838, the greatest productio being prior to 1900. By 1882, the vein had been worked to a depth of 570 feet. There has been no production for a great number of years. The New Jersey Zinc Company core-drilled the property in 1942. Nineteen holes, totaling 5,971 feet, were drilled. In 1952, a small amount of exploratory work was done, and one hole was drilled.

Redmond Prospect: The Redmond prospect is in northern Haywood County, about 3 miles southeast of Waterville Dam on the Pigeon River and 12 miles north of Waynesville. Since its discovery in 1905, considerable development work has been done, but there has been little production.

The ore contains galena, sphalerite, chalcopyrite, and minor amounts of fluorite. The higher grade ore is reported to carry 6 to 7 percent lead, 1.5 percent zinc, and 0.5 percent copper. Lower grade ores carry from 0.5 percent to 1 percent lead and about 0.5 percent each of zinc and copper.

The deposit consists of a system of disconnected sulphide-bearing quartz lenses, which lies along a fracture zone between the Max Patch granite and Snow Bird slates. The mineralized zone is reported to be from 10 to 14 feet wide and has been exposed for more than 250 feet. It was mapped in 1943-1944 by members of the United States Geological Survey. Their report is on open file in the Division of Mineral Resources of the North Carolina Department of Conservation and Development.

Some of the principal activities carried out on the property are:

1905: Discovered by R. J. Rathbone, who did a small amount of prospecting and sunk a shallow shaft.
1929-1930: United States Smelting, Refining, and Mining Company completed a shallow shaft and several trenches.
1939-1943: Development work by the Haywood Mining Corporation and a shipment of 44.5 tons of ore in 1940.
1951: Limited exploration by core-drilling carried out by the Hitchcock Corporation.

Little Hungary River Area: This lead prospect is located near the headwaters of Little Hungary River in Henderson County. It is 8.5 miles N. 72° E. of Hendersonville and about a mile downstream from Copper Ford. This occurrence was discovered about 1932, and prospecting has been carried out intermittently since that time. In 1949, it was inspected by geologists of the Tennessee Valley Authority. Pardo Mines, a Hendersonville company, prospected in the area during 1952 and 1953 and put down several diamond-drill holes. The ore is of the complex type, consisting of galena, sphalerite, chalcopyrite, and pyrite. There has been no production recorded from this prospect.

Cabarrus County: In Cabarrus County, A. L. Nash of Kannapolis prospected several of the old mines. The Nugget Mine near Georgeville was cleaned out, but no development work was done. Mr. Nash sampled the Allen Furr Mine in 1954, and the United States Bureau of Mines drilled one hole on the property, encountering a 4-foot vein at about 140 feet below the surface.

House Property: This property is in southwestern Halifax County, about 3 miles southeast of Essex and 2 miles east of the intersection of N.C. Highways 43 and 561. There, a relatively rich complex sulphide ore occurs in a small vein-type deposit. The ore is composed for the most part of galena, gold, chalcopyrite, and pyrite in quartz. This property has been prospected at various times, but there has been little production. About 1946, the United States Bureau of Mines drilled an exploratory hole on the property. During 1952 and 1953 the property was opened and some of the ore concentrated near Enfield. These concentrates were relatively rich in gold and lead. By 1954, this and adjacent properties were being studied in detail by industrial geologists.

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MANGANESE

Manganese, next to iron, is the most important of the strategic materials. No method has been developed or making steel commercially without it, approximately 13 pounds of manganese being required for every ton of steel produced. In steel it helps to correct the adverse effect of sulphur, has important alloying effects, and removes oxygen. Approximately 96 percent of the manganese consumed in the United States is for metallurgical purposes. Manganese is also used in dry batteries, chemical compounds, fertilizers, glass, paint pigments, and dyes. Although the United States contains large quantities of manganese ores, they are o such low grade that they cannot be marketed economically. Domestic sources account for only about 7 percent of the annual requirements of the nation. Most of the imports are from Cuba, India, South Africa, th Gold Coast, and Mexico.

Deposits of manganese are distributed quite generally throughout the Piedmont and Mountain regions o North Carolina, being found as far east as Zebulon, Wake County, and as far west as Murphy, Cheroke County. Some of them contain large tonnages of low-grade ore but are of a type which has not been amenable to economic concentration; others are vein-type occurrences which are quite rich locally but do not contain suitable reserves to maintain production. The principal occurrences of manganese in North Carolina classified according to origin, are described in the following sections, most of which were taken from Economic Paper 65 of the North Carolina Department of Conservation and Development:

Secondary Oxides Derived from the Weathering of Primary Manganese Silicates, Mainly Spessartite These deposits include the large manganiferous schist zones in the Kings Mountain area, which extend as tw erratic belts southwestward and southward from Bessemer City into Cherokee County, South Carolina. Samples of typical ore from four of the better localities in this area averaged 14 percent manganese. A somewhat similar body of manganiferous schist occurs on the south side of Vineyard Mountain near Shootin Creek in Clay County.

There are other deposits of the spessartite type which differ from the Kings Mountain variety in that the do not visibly incorporate any manganiferous phase of slate or schist. These have been derived from th weathering of hydrothermal veins composed predominantly of quartz and spessartite. One such deposit i on the Avon Privette property in Wake County, about 3 miles east of Zebulon. A similar deposit is in easter Surry County, about 12 miles west of Mount Airy and 4 miles north of Dobson, near N.C. Highway 89, on th property of R. E. Freeman. In Cherokee County, about a mile south of Murphy at the headwaters of Marti Creek, is a deposit known as the Yeager property; here, the manganese occurs in a vein which is dominantl quartz with small amounts of manganese oxides disseminated through it.

Primary Ore Bodies Composed of Manganese Silicates but Occasionally Carrying Manganese Carbonates: In Alleghany County, about 3 miles north of Sparta, there is a manganese occurrence on a small hill, locall known as Crouse Knob, which is somewhat similar to the spessartite deposits of Wake and Surry Countie but, in addition, it carries the manganese carbonate, rhodochrosite, and other manganese silicates.

Secondary Oxides Derived from the Weathering of Manganiferous Limestones: In Transylvania Count several manganese deposits appear along the outcrop of a crystalline limestone lens in the Brevard schis Their general location is about 6 to 10 miles northeast of Brevard and near the Buncombe County line. Th best known of the deposits is on the R. N. Lobdell property, along N.C. Highway 280, 7 miles northeast o Brevard. In western Madison County, there are several occurrences of manganese along the contact betwee Cambrian limestones and underlying quartzites. They are situated a short distance south of U. S. Highwa 70, in the valley of Upper Shut-in Creek not far from the Tennessee State Line.

Fluvial Terrace Deposits of Manganese Oxides: The only known occurrence of this type is the North Co deposit in McDowell County, about 12 miles north of Marion and one-half mile east of Pitts Station of t C. C. & O. Railroad. The ore is essentially a low-grade mixture of clay and soft, earthy manganese oxid with occasional nodules of harder ore.

Manganiferous Magnetites: Certain of the magnetic iron-ore deposits of Ashe County carry considerab portions of manganese oxides. The most outstanding of these is on the Ballou property on Piney Creek, 0 mile upstream from the intersection of the Piney Creek and Lansing roads. An analysis of the typical ore i MnO_2, 6.02 percent; Fe_2O_3, 92.45 percent; and acid insolubles, 0.81 percent.

Sporadic attempts have been made to mine and concentrate manganese in North Carolina for more tha fifty years, but in most cases such attempts have been unsuccessful, as is indicated by production recor shown in the accompanying table.

MANGANESE AND MANGANIFEROUS ORES SHIPPED FROM MINES IN NORTH CAROLINA FROM 1900 THROUGH 1945.

Year	Ore Containing 35 Percent or More Manganese Long Tons	Ore Containing 10 to 35 Percent Manganese Long Tons
1900	......	......
1901	......	20
1902-1916	......	......
1917	102	......
1918	315	30
1920-1924	......	30
1925	17	......
1926	55	......
1927	......	......
1928	10	......
1929	......	......
1930	60	......
1931-1938	......	......
1939	43	51
1940	......	190
1941	31	155
1942	......	......
1943	127	105
1944-1945	......	......
Total 1900-1945	760	581

Most of the activity was during World War I and World War II. Between 1939 and 1945, manganese was produced in small amounts from the North Cove, Zebulon, and Crouse Knob Mines. The United States Bureau of Mines and Tennessee Valley Authority carried out beneficiation tests on some of the ores during this period. Early in 1942, the American Chemical Company of Raleigh built a plant in that city and made a small amount of sulphate; however, the plant did not reach production stage. This company mined ore from the North Cove deposit and produced a small amount of metallurgical grade ore between the years 1946 to 1953. Concentration tests on the Kings Mountain ores were carried out also.

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MOLYBDENUM

Molybdenum is used chiefly as an alloy in iron and steel where it increases strength and ductility. Molybdenum steels are used in high-speed tools, dies, wire, aircraft, automobiles, armor plate, guns, and other products. Small amounts are used in making dyes and chemicals. Most of the domestic production comes from Colorado, Utah, New Mexico, and Arizona. The chief ore mineral is the sulphide, molybdenite.

In North Carolina, interesting occurrences of molybdenite are found in Halifax County, approximately 3.5 miles east of Hollister and 12 miles southwest of Littleton. It is associated with a small granite body about two miles long and is most highly concentrated in a series of quartz veins, although minor amounts are present in the granite and adjacent schist. Other vein minerals include pyrite, chalcopyrite, and sericite. The most important areas are the Boy Scout-Jones properties, about 2 miles south of Brinkleyville, and the Moss-Richardson properties, 3.5 miles east of Hollister.

The presence of molybdenum in the area was recognized first about 1935. In 1939, American Zinc Company sampled veins on the Jones property. Considerable prospecting was conducted early in 1943, and one 10-foot pit and a 30-foot shaft were excavated. During and immediately following World War II, the United States Bureau of Mines explored the deposits. The project began in July 1943 and continued until January 1944. It was resumed in July 1946 and continued until December 1946. During this period, 950 linear feet of trenches were excavated, 32 diamond-drill holes, totaling 7,701 feet, were drilled, 30 trench sample were collected for assay, and 1,447 drill samples were obtained, 309 of which were assayed. Results of thi work indicate that there are an estimated 549,300 tons of induced or inferred ore, having an average MoS content of 0.45 percent. This property was inspected by several companies during the years 1946-1953, bu there was no record of additional prospecting or exploration.

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NICKEL

Nickel ranks second only to manganese among the ferroalloys. Its chief use is in nickel steels and nick cast irons, but it is also alloyed with copper (Monel metal), brass, bronze, aluminum, chromium, and othe metals. Nickel imparts to its alloys strength, toughness, lightness, corrosion resistance, and electrical an thermal properties. Nickel steels are used widely for structural purposes, armor plate, and as moving part for many types of machines. Stainless and anticorrosion steels are important in the automotive, aviatio and railway industries. Nickel is also used for coinage and plating. Of the total domestic consumptio about 45 percent is used in the manufacture of ferrous alloys, 32 percent for nonferrous alloys, 9 percent fo heat and electric-resistant alloys, and 12 percent for plating.

There are no known commercial deposits of nickel in the United States. Of the total domestic consumptio of nickel, a small amount is recovered as a byproduct in the United States, but most of it is imported fro Canada. Nickel minerals have been found at a number of locations in the United States, but the outstand ing occurrences are those near Riddle, Oregon, and Webster, North Carolina.

Small amounts of the nickel silicate minerals, garnierite and genthite, are associated with several of th dunite masses in Western North Carolina. The most important occurrence is east and south of Webste Jackson County. There, a nickeliferous zone, some 500 feet wide and about 2 miles long, occupiess the inn edge of a large L-shaped dunite dike. The richer concentrations are near the old nickel mine site south of th Tuckaseigee River, about a mile south of Webster and near the eastern border of the dike just east of We ster.

An average analysis of samples taken from prospect pits and trenches was reported by G. W. Pawel, a follows: SiO_2, 41 percent; MgO, 2.82 percent; FeO, 13.9 percent; NiO, 1.5 percent; Al_2O_3, 1.6 percen Cr_2O_3, 1.1 percent; MnO_2, 0.25 percent; and H_2O, 10 percent. Reserves are estimated in excess of 2,500,00 tons of one-percent ore.

Although attempts have been made to produce nickel from the Webster deposit, no way has been found a yet to concentrate the ore economically. About 1912 the Consolidated Nickel Company attempted to explo the deposit. The property was developed by means of about 60 open cuts and pits and one tunnel 154 fe in length. Some diamond drilling was carried out, one hole having been sunk to a depth of 162 feet. No pro duction was recorded. In 1942, 6 diamond-drill holes were put down by the Tennessee Valley Authorit Nickel ore was encountered to a depth of 117 feet. Detailed ore-dressing studies were carried out durin the early 1940's by G. W. Pawel and Julian H. Gillis of the Olivine Products Corporation and by the Te nessee Valley Authority. Results of these investigations indicate that ordinary concentration methods a unsatisfactory. Although a sound recovery process was worked out by the Tennessee Valley Authority, a percent or 3-percent ore would be necessary to make it economically favorable.

There has been little activity since 1942. Additional prospecting was carried out by Julian H. Gillis 1952. This work, financed by a DMEA loan, consisted of several bulldozer cuts and shallow shafts near t old nickel mine site. There has been no attempt to process the ore.

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TIN

Tin is one of the most important of the nonferrous strategic minerals. Its ability to form thin, ductile, noncorrosive and closely adhering films on steel and other metals, its antifriction properties, and its ability to act as a flux in binding one metal to another has made it essential to modern industry. The United States is the largest consumer of tin, the total consumption in 1951 by uses was, as follows: tin plate and terneplate, 35 percent; bronze and brass, 25 percent; solder, 22 percent; babbitt, 7 percent; and tinning, 3 percent. Domestic production of tin is insignificant, the total between 1942 and 1951 being approximately 280 tons, most of which was from Alaska and Colorado. Important sources of tin imports to the United States are Bolivia, Belgian Congo, Indonesia, and Thailand.

Cassiterite, an oxide of tin, is found in minor quantities associated with spodumene-bearing pegmatites within the Kings Mountain district of North Carolina. The pegmatites occur in a restricted zone which extends from near Lincolnton through Kings Mountain and into Cherokee County, South Carolina. According to T. L. Kesler, geologist who studied and mapped the deposits in detail, there are at least 91 deposits of potential tin ore in North Carolina and one near Gaffney, South Carolina. The tin content of the ore ranges from a trace to more than 6 percent and is highly irregular within each pegmatite. Although cassiterite is a persistent mineral throughout the zone, no major concentrations are known. Aggregate reserves in 55 of the better known deposits are estimated by Kesler at about 10 tons of metallic tin per foot of depth, although most of the deposits are too small to be mined.

Tin was discovered in North Carolina in 1883, and systematic prospecting of the Kings Mountain district began in 1886. Since that time there have been numerous investigations of the deposits and repeated efforts to develop commercial ore bodies. Production has been small and erratic but is recorded for the years 1903-04, 1906-07, 1910, 1912-13, 1918, 1931, 1937, 1944, and 1951-53. During 1941, Atlas Collapsible Tube Company of Chicago began prospecting the old Faires Mine near Kings Mountain and did considerable exploratory work, but the project was abandoned when the ore body proved too small for development. During 1941 and 1942, Ka-Ma-Tin Concentrating Company explored several pegmatites just south of Lincolnton, but no tin was produced. The Aurum Mining Company produced about 10 tons of ore from Gaston County in 1944.

During the 1946-1953 period the possibilities of recovering tin economically were revived, when Foote Mineral Company began concentration of spodumene by flotation methods during 1951. Between 1951 and 1953, tin was produced as a byproduct of spodumene concentration, but the tonnage has been small.

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TITANIUM

Titanium is not a rare element, ranking as the ninth most abundant in the earth's crust. Although it is present in over 60 mineral species, the greatest concentrations are in the minerals rutile (TiO_2) and ilmenite (Fe,TiO_3), the former containing 60 percent titanium and the latter 31.6 percent when pure. Ilmenites and titaniferous magnetites are the most importance sources of commercial titanium.

Approximately 99 percent of all titanium consumed in the United States is used in making pigments. Other uses include in the manufacture of alloys, welding rod coatings, carbide, ceramics, as a steel flux or deoxidizer, and as lamp electrode coatings. In 1947, titanium metal, long a metallurgical curiosity, was first produced on a limited commercial scale. Since that time there has been an enormous demand for it. Its corrosion-resistant properties and strength at high temperatures make it highly desirable for many uses, especially in jet aircraft construction. Within the next few years a tremendous expansion in the production of titanium metal is predicted.

DISTRIBUTION IN NORTH CAROLINA

Titanium minerals are common throughout many sections of North Carolina, but deposits of possible e nomic importance are restricted to a few areas. The more outstanding known occurrences are: (1) len of granular ilmenite north of Lenoir in Caldwell County, (2) placer rutile in the Elf-Shooting Creek area Clay County, (3) ilmenite-magnetite lenses in Ashe and Guilford Counties, and (4) ilmenite sands in t Coastal Plain region, especially in Beaufort, Gates, Chowan, and Perquimans Counties.

Caldwell County: Deposits of high-grade ilmenite occur approximately one mile north of Finley P Office in northern Caldwell County. They consist of a series of narrow, closely spaced lenses which form nearly continuous vein about a thousand feet long. Core-drilling has proved the ore extends to a depth 200 feet and has a maximum thickness of 35 feet. The ore consists of small masses of ilmenite dissemina throughout a talcose body which lies conformably with the enclosing quartzite and mica schist.

In January 1942, Yadkin Valley Ilmenite Company, a subsidiary of the Glidden Company, started mini operations at this locality. Mining was by open-cut methods, and the ilmenite was concentrated by vari stages of crushing, scrubbing, and screening. Concentrates averaged about 51 percent TiO_2 (30.9 perc Ti.). Mining was restricted to relatively soft ore in the upper part of the deposit, the cost of mining and c centrating the hard underlying ore being considered excessive. The plant was closed in October 1952, af most of the soft ore had been removed. Production for the period of operation is shown in the table, wh also represents the total production of ilmenite in North Carolina for the same years.

TITANIUM CONCENTRATES (SHORT TONS) PRODUCED IN NORTH CAROLINA 1942-1952

1942	3,323	1948	28,990
1943	5,341	1949	31,364
1944	14,908	1950	26,543
1945	17,641	1951	24,928
1946	17,102	1952	24,928
1947	27,349		

Clay County: A garnetiferous mica schist, carrying varying amounts of rutile, extends from near H Clay County, North Carolina, to Young Harris in neighboring Towns County, Georgia. The rutile-bear phase of the schist is irregular and not present everywhere. Although at no point has rutile been found commercial quantities in the schist, several small placer deposits in the Shooting Creek area have been pr pected and some attempts made to recover the rutile from them. None of the operations have proved s cessful. Geologic investigations of the placer deposits indicate that the principal known deposits aggreg approximately 950 acres and represent over four and one-half million tons of rutile-bearing material. Sa ples taken from some of the old prospect pits contained about 20 pounds of rutile to the cubic yard of ore. T area has been prospected recently by power-driven augers, but results are not available for publication.

Ashe County: Deposits of titaniferous magnetites occur in a narrow belt extending from Little Hel Creek, near the Virginia state line, southwestward to Helton Creek, near Sturgills, a distance of 2.5 mi Ore bodies consist of overlapping lenses of titaniferous magnetites associated with hornblende gneiss. One the better known deposits is on the Young property, located on Little Helton Creek about one-fourth o mile downstream from the state line. Here, individual lenses of magnetite are as much as 100 feet long 25 feet wide and form a more or less continuous zone for nearly 2,000 feet. Analyses of selected specim of the ore showed TiO_2 contents of 4.95, 8.80, 9.17, and 12.96 percent. Samples from other properties in A County had TiO_2 contents of 6.03, 5.54, 8.91, 5.38, and 9.11 percent. Small amounts of rutile are present some of the ores.

Guilford County: A narrow zone of titanium-bearing magnetite extends across western Guilford Cou The ore consists of intergrowths of magnetite and ilmenite and, in some instances, considerable amount rutile. This belt of ore was worked for iron on a limited scale at several points. One of the better kn openings is the Tuscarora Mine, one mile north of Friendship in Guilford County. Analyses of ores fro localities give the percentage of TiO_2 as 13.60, 13.71, 13.52, 11.95, 12.35, and 15.35. The ore bodies are a se of elongated lenses. In most cases they are quite small, and their commercial possibilities as a source titanium are as yet to be demonstrated.

Coastal Plain: Ilmenite and other heavy minerals occur in various concentrations in the sands of the Coastal Plain region. In most cases the ilmenite content is low, but there is a wide distribution of the material. Ilmenite sands of possible commercial interest are known in but a few localities. Among the more important of these are: (1) in the vicinity of Edward, Beaufort County, (2) along the shores and in the bottom of parts of Albemarle Sound, and (3) east of Sunbury in Gates County. A small but relatively high concentration is located near the northern end of Topsail Island, Onslow County.

Since 1942 there has been considerable interest in the ilmenite-bearing sands of the Coastal Plain. On January 26, 1942, E. I. du Pont de Nemours and Company obtained a nonexclusive lease from the State of North Carolina to prospect for ilmenite in and along Albemarle Sound. On January 22, 1946, this lease was renewed and expanded to cover all sounds and rivers in the coastal area of the state as far south as the Cape Fear River. After some exploratory work, this project was abandoned. On November 21, 1951, the State granted to National Lead Company a lease to investigate the ilmenite sands along the coastal areas of North Carolina and a similar lease was granted to Burnup and Sims, Incorporated, on March 5, 1952. National Lead Company carried out a somewhat extensive prospecting program in the northeastern counties and along the outer banks. Concentrations of possible economic interest were found along some of the old beach ridges inland from Pamlico Sound. No attempts have been made to concentrate ilmenite from these sands on a commercial scale.

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TUNGSTEN

Tungsten is one of the more important alloy metals. It is the heaviest of the base metals and has the highest melting point and modulus of elasticity of all metals. Tungsten is used in making high-speed cutting steels, lamp filaments, electrical apparatus, electrical contact parts, radios, X-ray equipment, textiles, pigments, armor plate, guns, and projectiles. Tungsten carbide, next to diamond the hardest known cutting agent, has become increasingly important. Since 1950 over 50 percent of the domestic consumption of tungsten concentrates has gone into making tungsten metal powder, the raw material from which tungsten carbide is produced. For the period 1945-1951, 37 percent of the tungsten concentrates consumed in the United States was converted into ferrotungsten for use in steel, 19 percent went directly into steel, and 44 percent was used in the preparation of tungsten metal powders and for other uses.

TUNGSTEN CONCENTRATES PRODUCED FROM THE HAMME DISTRICT, NORTH CAROLINA, FROM 1943 TO 1953*

Year	*Concentrates (Short Tons)*	*Percent* WO_3
1943	40	70.0
1944	321	35.0
1945	219	37.9
1946	349	51.3
1947	585	59.2
1948	969	58.3
1949	921	61.4
1950	1,086	60.0
1951	1,145	54.0
1952	1,468	51.0
1953	2,323	54.8
	Total 9,426	Average 53.9

*U.S. Bur. Mines Minerals Yearbooks and unpublished statistics, 1943-1953.

There are twelve known tungsten minerals, but wolframite, huebnerite, scheelite, and ferberite are t only ones of economic importance. Heubnerite ($MnWO_4$) and scheelite ($CaWO_4$) are the principal tungst minerals found in North Carolina.

Although the presence of these minerals was reported in the state as early as 1900, it was not until 19 that deposits of commercial value were discovered. Since 1943 North Carolina has been an important produc of tungsten concentrates, ranking second in the nation in 1947, 1948, and 1950 and third in 1946, 1949, 19 and 1953. Other major producing states are California, Colorado, Idaho, and Nevada.

OCCURRENCE IN NORTH CAROLINA

In North Carolina, tungsten minerals have been found in two principal localities. One is in northweste Vance County, and the other is in Cabarrus County. (See Fig. 6.) The total production in North Ca lina is from the Hamme Mine in Vance County.

Vance County: The only known deposits of tungsten which have proved to be commercially important a those about 2.5 miles west of Townsville in northwestern Vance County. These consist of a series of m eralized quartz lenses within a rather pronounced zone of fracture near the contact between granite a rocks of the Volcanic-Slate series. Huebnerite and scheelite are the predominating tungsten minerals a are associated with varying amounts of sphalerite, pyrite, chalcopyrite, galena, tetrahedrite, rhodochros and fluorite. The ore averages less than 1-percent WO_3.

These deposits were found in 1942 by Joseph and Richard Hamme, who worked them on a small scale u August 1943, when the properties were acquired by Haile Mines, Incorporated. Tungsten Mining Corpo tion, formed by Haile Mines, Incorporated, and General Electric Corporation assumed control of min operations in June 1945. The property has been developed rapidly since about 1947, and since 1951 the m has been the largest single producer of tungsten concentrates in the United States.

Underground operations consist of two principal shafts—Central and Snead—from which the deposi have been developed by drifts at various levels. By the end of 1952 the Central Shaft had been sunk t depth of 994 feet and the Snead Shaft to a depth of 885 feet. From 1948 through 1952 the company had co pleted 73,908 feet of core drilling and 41,103 feet of underground development.

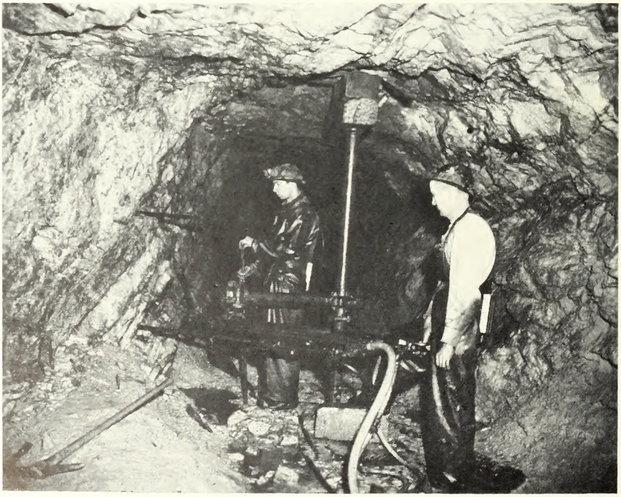

FIGURE 6. MINING TUNGSTEN AT HAMME MINE, VANCE COUNTY.

At the plant the ore is concentrated by crushing, screening, jigging, tabling, drying, and magnetic separating. Flotation is used to remove most of the sulphide minerals. Final concentration is by magnetic separation, which divides the concentrates into three usable products: high-grade huebnerite, averaging 70 percent or more WO_3; a middling product, containing huebnerite, scheelite, and other minerals and averaging from 15 to 20 percent WO_3, and a low-grade scheelite concentrate, containing from 15 to 20 percent WO_3. Scheelite concentrates, middlings, and dust are shipped out of the state for upgrading by chemical treatment. As a result of plant expansion, production was nearly doubled during 1952 and 1953.

The Hamme Tungsten district has been the object of various geologic investigations, and several reports have been published. That part of the district lying in North Carolina is being mapped in detail by members of the United States Geological Survey as part of a cooperative project between that agency and the Division of Mineral Resources of the North Carolina Department of Conservation and Development.

Cabarrus County: Small amounts of scheelite have been found at several old gold and copper mines in Cabarrus County. Among these are the California, Phoenix, Furniss, Flowe, Cline, and Crosby. Although economic amounts of tungsten are yet to be found, the occurrence is of considerable interest, and more detailed work in the area is warranted. The scheelite occurs in mineralized quartz veins close to the contact between quartz-diorite intrusives and rocks of the Volcanic-Slate series. Most of the veins are in the volcanic rocks. Minerals associated with the scheelite include pyrite, chalcopyrite, barite, siderite, calcite, and native gold.

Some of the occurrences have been prospected and a few exploratory holes drilled. In 1946, the United States Bureau of Mines drilled 4 diamond-drill holes at the Cline Mine, and from 1948 to 1950 this agency drilled 12 holes, totaling 1,786.6 feet, at the Furniss Mine. Considerable prospecting was carried out by A. L. Nash and J. I. Moore, Jr. R. S. Houston of the Division of Mineral Resources of the North Carolina Department of Conservation and Development did detailed geologic mapping near the Furniss Mine during 1949.

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NONMETALLIC MINERALS

ABRASIVE MATERIALS

Natural abrasives are those minerals and rocks used directly as grinding, abrading, polishing, and scourng or cleaning agents and applied usually by a rubbing action or impact. They are used in untreated orms, except for normal crushing, beneficiation, and sizing or bonding. To qualify as a natural abrasive, material must possess certain properties of hardness and toughness, proper grain or particle size and shape, uitable fracture or cleavage characteristics, and a high degree of uniformity and purity. Stability at high emperatures and chemical inertness are desirable for some uses.

Abrasives are used as loose grains and powders, as bonded grains made into various shapes, as surface-oated grains, and as massive pieces cut to specifications. Industrial applications are widespread and vary widely with the type of abrasive material. As loose grains and powders, abrasives are used for surfacing nd polishing stone and glass, sand blasting, wire saw cutting, drilling, cleaning and scouring compounds, tooth powders, and on wheels for grinding and buffing. Coated grains are used in abrasive papers and cloths. Bonded grains and massive stones are used for grindstones, grinding wheels, and hand-sharpening stones.

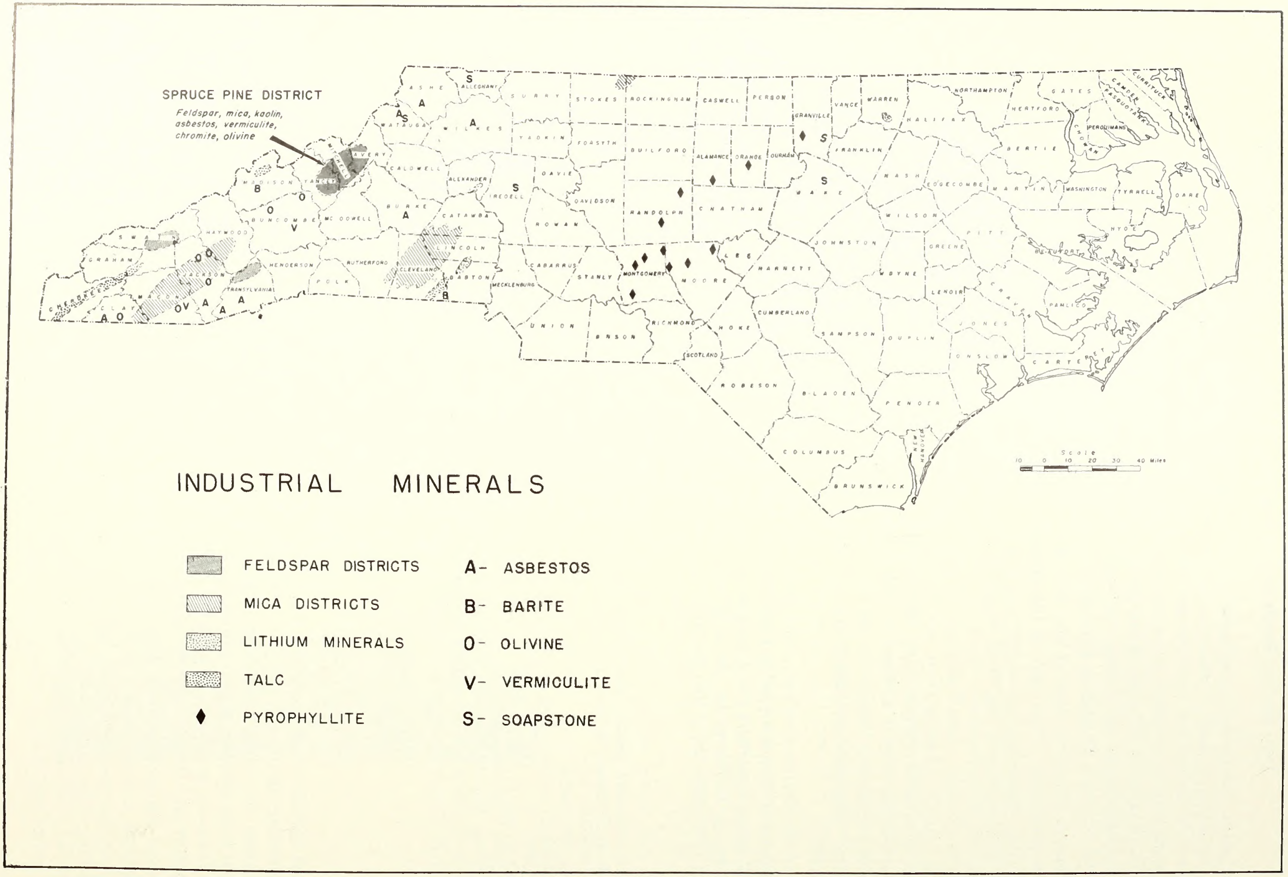

FIGURE 7. INDUSTRIAL MINERALS.

The massive materials are also used as millstones, chaser stones, tube-mill lining, and grinding pebbles. Within the past few years manufactured or synthetic abrasives, possessing great purity and uniformity, have been marketed on a large scale and have replaced the natural materials for many uses; however, top-quality natural abrasives are still in demand.

Natural abrasives found in North Carolina include corundum, emery, garnet, quartz, quartzite, and granitic rocks. Talc and feldspar have been used to a limited extent.

Corundum: Corundum (Al_2O_3) is, next to diamond, the hardest natural abrasive. It hase been found at more than 60 localities in North Carolina and is a rather common mineral in parts of Clay, Macon, Jackson, Transylvania, Alexander, Catawba, and Iredell Counties. Deposits which have been worked on a commercial scale are limited to the first four counties named and include the following mines: Corundum Hill and Miney Mine in Macon County; Buck Creek in Clay County; Socrates, Bad Creek, and White Water in Jackson County; and Burnt Rock and Brockton in Transylvania County. The more important deposits are associated with peridotite masses, where they occur as peripheral and interior veins and often have been subjected to varying degrees of pegmatitic activity. The mining of corundum first started at Corundum Hill, Macon County, in 1871 and flourished for several years; however, except for a small sporadic production, there has been little activity since 1905.

Emery: Emery is a mechanical mixture of corundum and magnetite or hematite. It has been found in minor quantities in Macon, Yancey, and Guilford Counties, and a small production was reported from Macon County in 1918. There has been no recorded production since that time.

Garnet: Garnet for abrasive use has been produced on a small scale from several localities in North Carolina, but deposits of a grade suitable to compete economically with production from other areas have not been found in recent years. A considerable amount of pink (rhodolite) garnet was mined on Sugar Loaf Mountain near Willetts in Jackson County, the greatest productive period being between 1900 and 1926. Other localities of occurrence are near the headwaters of Shooting Creek in Clay County, near the headwaters of the Nantahala River in Macon County, and along Little Pine Creek, south of Marshall in Madison County. The last recorded production of garnet in North Carolina was in 1944 and was a byproduct of milling kyanite in Yancey County.

Millstones and Chaser Stones: Millstones are flat, circular stones used for general grinding purposes. They operate in pairs on a horizontal plane, one stone on top of the other. The lower is stationary, and the upper rotates to produce the grinding action. Such mills were developed for grinding grain but were adapted for fine-grinding soft minerals, such as talc and gypsum. Chaser stones are large, flat wheels, usually 5 to 6 feet in diameter and 18 to 22 inches in thickness, used for coarse-grinding nonmetallic minerals and ores. The chaser-type mill consists of a basal plate of tough stone a foot or more in thickness upon which one or more chaser stones travel. These stones run on edge in a circular path and are turned from a central shaft. This type of mill was in wide usage at one time but has been replaced largely by more efficient units. Millstones and chaser stones are made of any hard suitable rock, varying from sandstones and quartz conglomerates to granites and basalts. They are manufactured at a number of localities, but the preparation of the larger chaser stone has practically ceased.

In North Carolina millstones and chaser stones have been made from quartz conglomerate at Parkwood (now abandoned) in Moore County and from granite, near Faith in Rowan County. During the period 1946-1953 the only producer of millstones was the Gardner Granite Works at Faith.

Tube-Mill Lining and Grinding Pebbles and Blocks: In cylindrical and conical mills in which feldspar and other ceramic materials are ground, it is necessary to have hard, inert linings and grinding media to prevent contamination of the finished product. High-quality flint is often used, and since 1940 certain types of granite have become important for this purpose. During World War II, Southern Products Silica Company, Milesville, and W. R. Bonsal Company, Hamlet, produced quartz (silica) grinding pebbles, the last recorded production being in 1946. Tube-mill liners and grinding blocks of granite are quarried near Salisbury in Rowan County. During the period 1946-1953, Harris Granite Quarries, Peeler and McCombs, and W. S. Lippard were the producers of granite mill liners and grinding blocks. Because of the small number of producers, individual production figures of the various abrasive materials cannot be revealed. However, the average annual value of all abrasive materials produced in the state from 1946 to 1953 was approximately 20,775.00.

ASBESTOS

Asbestos is a general term applied to the fibrous varieties of several minerals, including chrysotile, a se pentine, and the amphiboles anthophyllite, amosite, crocidolite, tremolite, and actinolite. These minera differ widely in composition and properties. The commercial value of asbestos depends to a great degr upon the physical property of the mineral which allows it to be separated into fine filaments of high tens strength and flexibility and to its incombustibility. Of the asbestos minerals, chrysotile is the most impo tant and represents the bulk of that consumed by industry. Asbestos occurs as cross fibers, slip fibers, a in massive form. In cross-fiber veins, the fibers are approximately at right angles to the vein walls. This the most common occurrence of chrysotile. The slip-fiber forms parallel to the enclosing vein walls. Bo chrysotile and the amphibole varieties occur in this manner. Massive asbestos consists of a series of u oriented fibers and is the usual occurrence of anthophyllite.

The uses of asbestos are many and diverse. According to use there are two principal types, the mediu and long fiber, classed as spinning asbestos, and the short, more brittle varieties, classed as nonspinnin The spinning varieties are consumed chiefly in the manufacture of cloth and packing, the most importa use being in automobile brake and clutch linings. The nonspinning type is used largely by the building trad in asbestos cement products, shingles, siding, paper, floor tiles, and other products. Anthophyllite, th principal asbestos mined in North Carolina, is a constituent in chemical filters, welding-rod coatings, and pi coverings.

Asbestos occurs in basic-rock formations at many localities throughout the western Piedmont and Mou tain regions of North Carolina. Anthophyllite is the most common variety, although chrysotile is found at number of places. In general, the deposits are small and sustained production is difficult; however, whe several deposits are located in the same vicinity, the asbestos can often be produced economically. Most the production in North Carolina has come from two parts of the state: the Cashiers area, comprising par of Macon, Jackson and Transylvania Counties, and the Spruce Pine district, which includes Avery, Mitche and Yancey Counties. Asbestos was mined intermittently for a number of years from near Frank, Ave County, and was processed at nearby Minneapolis. Deposits have been worked near Green Mountain, th Cane River section, and Micaville in Yancey County. One of the largest occurrences is known as the Bl Rock deposit and is located along the South Toe River, about 2 miles southeast of Micaville. Considerab tonnages have been mined from numerous small deposits near Cashiers, Glenville, and Lake Toxaway southern Jackson and Transylvania Counties and in the extreme southern part of Macon County.

Although North Carolina's annual production of asbestos is small and intermittent, the state has been producer for more than fifty years and has made important contributions to the domestic supplies of anth phyllite. During the period covered by this report, asbestos production is recorded for 1945, 1947, 1948, 195 1951, and 1953. Prior to 1950, most of the tonnage was from a single deposit in southern Macon Count since 1950, deposits have been opened up in Transylvania County. Most of the mining has been by the Po hatan Mining Company, Woodlawn, Baltimore, Maryland. The Industrial Minerals Corporation, Ashevi North Carolina, did considerable prospecting and development work in the Spruce Pine district. By 195 the Mining & Milling Corporation of America had reopened the Blue Rock deposit. The asbestos is truck to Spruce Pine for milling, the plant site being at the old Minpro railroad siding.

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BARITE

Barite, also known as barytes and heavy spar, is a sulphate of barium ($BaSO_4$) and theoretically contai 65.7 percent BaO and 34.3 percent SO_3. It is usually light colored but ranges from white and brown to near black. It is characterized by its softness (2.5 to 3.5) and high specific gravity (4.3 to 4.6). Commerci barite usually contains varying amounts of impurities, such as silica, dolomite, iron oxides, and various su phide minerals.

The largest use of ground barite is as oil-well drilling mud. Other uses are as a pigment and extender paint; as a flux, deoxidizer, and decolorizer in making glass; in ceramic glazes and enamels; in the manufa ture of lithophone, used widely in paint and rubber products; in the preparation of various barium chemicals, and as a filler in many products, including paper, cloth, linoleum, oilcloth and artificial ivory and buttons. It has many miscellaneous uses.

Most of the domestic barite is produced in Arkansas, Missouri, Georgia, and Tennessee. There are several occurrences in North Carolina which have been worked on a commercial scale. Among the more outstanding of these are the deposits near Hot Springs in Madison County and those south and west of Kings Mountain in Cleveland County.

Hot Springs Area: The largest known occurrences of barite in North Carolina are those in the vicinity of Stackhouse, 3.5 miles east of Hot Springs, Madison County. Deposits are found in an area which extends for approximately 8 miles from near Bluff, 4 miles south of Hot Springs, on N. C. Highway 209, northeastward down Doe Branch, across the French Broad River at Sandy Bottom, and to approximately one-half mile northeast of Walnut Gap on U. S. Highway 70.

The barite occurs in veins, pods, stringers, and as small disseminated aggregates in the country rock. The principal deposits are fracture fillings and are localized along thrust faults or adjacent zones of fracture. The barite is white, gray, and pink and is associated with quartz, fluorite, sericite, pyrite, chalcopyrite, and calcite.

Although the deposits were known as early as 1818, production was not started until 1884, when the first mill was erected at Hot Springs. Mining continued at intervals until 1927, the greatest period of production being from 1904 to 1916. Most of the production was from the Stackhouse group of mines, and a sizeable tonnage was reported to have come from the Long Mountain Mines near Bluff. It is estimated that at least 300,000 tons of barite have been produced from the district. During a flood in 1916, the mill of the Carolina Barytes Company at Stackhouse was washed away and never replaced. From 1916 until 1927, production was sporadic. No barite has been mined in recent years.

In 1944 the United States Bureau of Mines conducted a drilling program on the A. G. Betts property (Sandy Bottom Mine) in an attempt to prove the southward extenstion of the large ore body at the Stackhouse Mine. Four holes, averaging 319 feet deep, were drilled along a line some 150 feet east of the Betts Shaft and extending approximately S. 11° W. for a distance of 700 feet. All were toward the northwest at angles ranging from 48° to 76°. No extensions of the ore body were reported. Results of this work are published in Report of Investigation 4571 of the United States Bureau of Mines.

During 1948 the North Carolina Department of Conservation and Development and the Tennessee Valley Authority sponsored jointly a detailed geologic mapping program of the Hot Springs area. Results of this survey, including descriptions of barite occurrences, are published as Bulletin 60 of the North Carolina Department of Conservation and Development. In 1951 A. G. Betts reopened the lower tunnel of the Sandy Bottom Mine to inspect manganese occurrences.

Kings Mountain Area: Barite occurs in a narrow irregular zone which extends from the northeastern flank of Crowders Mountain, 4 miles east of Kings Mountain in Cleveland County, southwestward to about 5 miles beyond Gaffney, South Carolina. The barite is restricted largely to a quartz-sericite schist, which lies near the contact of the Battleground schist and Bessemer granite and is considered to be of hydrothermal origin. Deposits consist of stringers and lenticular masses of barite from 0.5 of an inch to about 2 feet thick, which parallel in general the schistosity of the enclosing rock, and as finely disseminated aggregates within the schist.

Small-scale prospecting and mining have been done at a number of localities, but most of the production from that part of the barite belt in North Carolina has come from the Lawton property, located along the southeast side of Crowders Mountain, 4.3 miles east of Kings Mountain. There, the barite occurs in a zone some 2,600 feet long which trends about N. 16° E. It is associated with quartz, galena, sphalerite, and sericite. Early records of the mine are incomplete, but some ore was produced from 1900 to 1907. A small amount of development work was carried out in 1915, but there is no record of production. In 1924, Bertha Mineral Company sank two shafts, approximately 200 feet deep and 650 feet apart, and drifted along a vein until the shafts were connected. Since 1924, there has been little work on this property.

In 1947, the Tennessee Valley Authority, cooperating with the North Carolina Department of Conservation and Development and the South Carolina Research, Planning, and Development Board, carried out geologic investigations and beneficiation tests on the ore found within the Carolina Barite Belt. Results of these investigations, published as Bulletin 57 of the North Carolina Department of Conservation and Development, indicate that much of the low-grade barite ore within this zone can be concentrated successfully by standard flotation procedures.

Other Occurrences: Barite has been reported from several localities, but at no one has any tonnage been found. Approximately 3.5 miles southeast of Hillsboro, barite is reported in small quantities at the old Latta Mine. Occasional pieces of crystalline barite have been found associated with some of the pyrophyllite deposits, particularly the Staley deposit in Randolph County.

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CEMENT

Portland cement is prepared by calcining and heating to incipient fusion mixtures of natural materials which include calcium carbonate, alumina, and silica as essential ingredients. Prior to heating, a blended mixture generally lies within the following limits: 60-64 percent lime; 20-24 percent silica; 6-10 percent iron oxide; and 3-5 percent of other ingredients. By controlling the raw material mix, burning temperature, and time of heating, various types of cements can be produced. The principal raw materials required in the production of cement are high-calcium limestones and clays or shales, all of which occur in North Carolina.

One of the more important prerequisites for the establishment of a cement industry is the presence of a high-calcium limestone deposit of sufficient size and uniformity, located convenient to transportation facilities. Within the past several years considerable attention has been focused upon the suitability of the limestones in North Carolina for making cement, and several investigations have been carried out in an attempt to locate satisfactory deposits.

There are two basic types of limestone in North Carolina, the crystalline dolomitic varieties in the Piedmont and Mountain regions and the shell limestones and marls of the Coastal Plain. Sizable deposits of dolomitic limestones occur in Cherokee, McDowell, and Cleveland Counties, but because of the relatively high magnesia content, lack of uniformity, and size of the deposits they are generally undesirable as a high-grade cement raw material. The most important potential sources of high-calcium limestones are those in the Coastal Plain region, especially in Jones, Craven, Onslow, and Pender Counties. These consist of shell limestones and marls, which vary from 2 to more than 50 feet in thickness and often underlie considerable areas. Although impurities and excessive overburden make most of the material uneconomical to use, some of the deposits are quite pure and have been proved by exploration. Typical analyses of limestones from various localities in the State are present in descriptions of limestones beginning on page 72. Shales and clays are relatively abundant in the Piedmont region but are not common in the Coastal Plain.

North Carolina and Mississippi are the only southern states in which Portland cement is not manufactured. This situation has become of increasing concern to North Carolina since the state imports more than 3,500,000 barrels annually, valued at approximately $8,750,000.00. Under extreme economic conditions, temporary shortages have occurred, further accentuating North Carolina's dependance upon other areas as sources of supply. Several attempts have been made to remedy this situation.

As early as 1924, investigations of the marls and limestones east and south of the Trent River in Jones and Craven Counties revealed the presence of large reserves of a relatively high-grade material that appeared satisfactory as a cement raw material. An average analysis of 100 samples from the Dan Whitford property in Jones County showed 6.94 percent SiO_2, 0.58 percent Fe_2O_3, 1.56 percent Al_2O_3, 89.07 percent $CaCO_3$, and

1.1 percent $MgCO_3$. By 1926, the Carolina Cement Company of New Bern, headed by J. A. Acker, was constructing a cement plant designed to have an initial capacity of 1,500,000 barrels annually. Adverse economic conditions caused the project to be abandoned before the plant was completed.

The period of intensive construction following World War II caused temporary shortages of Portland cement in some areas of North Carolina, which resulted in renewed efforts to establish a cement industry in the state. Between 1946 and 1948, the Department of Engineering Research of the North Carolina State College, in cooperation with the North Carolina Department of Conservation and Development, carried out basic research and pilot-plant tests on the preparation of cement from North Carolina raw materials.

In an effort to guarantee the state a source of supply, the North Carolina General Assembly of 1949 passed House Bill 211, authorizing the appointment of a commission to investigate the possibilities of establishing a Portland cement plant in the state. This commission recommended that a study of available raw materials be made, and the project was begun in January 1950 under the joint sponsorship of the Department of Conservation and Development, the Highway and Public Works Commission, and the Department of Agriculture. The survey was carried out by G. W. Moore, under the supervision of the State Geologist and under the general direction of the Department of Conservation and Development. This survey, conducted principally in the Coastal Plain, resulted in the discovery of a large tonnage of high-grade marl and limestone near Maple Hill in Pender County. Preliminary drilling indicated the limestone to vary from 20 to 40 feet in thickness and to be overlain with from 2 to 8 feet of overburden. The following analysis is typical: SiO_2, 3.3 percent; Al_2O_3, 1.0 percent; Fe_2O_3, 0.8 percent, CaO, 50.7 percent, MgO, 0.9 percent, CO_2, 42.2 percent, and P_2O_5, 0.11 percent. Difficulties were encountered in finding suitable clay in the Maple Hill area.

Following investigations by the State of North Carolina, the Volunteer Portland Cement Company of Knoxville, Tennessee, carried out additional exploration and acquired leases on considerable acreage in the area around Maple Hill. As of 1953, investigations were under way to locate a suitable clay within economic hauling distance of the limestone deposits.

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CLAYS AND SHALES

The clay materials in North Carolina are of two principal types: (1) common clays and shales suitable for the manufacture of brick, tile, and other structural clay products, and (2) minerals of the kaolin group which constitute high-grade china clays. The former type is common throughout many parts of the state, but the latter is restricted in occurrence.

Brick and Tile Clays: Clay materials which can be used satisfactorily in the manufacture of common and face brick, hollow building tile, roofing and floor tile, sewer pipe, and other structural clay products are widespread in North Carolina. They include normal sedimentary clays, residual clays, and shales. Sixty-four of the 100 counties have shown a production of structural clays in the past, and practically every county has deposits suitable for the manufacture of common brick. The most widely developed structural clay materials are the large deposits of uniform shales and residual clays in the Piedmont and Mountain areas of the state.

The more important commercial-clay resources are: (1) the weathered slates of the Volcanic-Slate series, especially those in Davidson, Stanly, Montgomery, Anson and Union Counties; (2) The Rome shales near Hot Springs, Madison County; (3) weathered portions of the Brevard schist in Henderson County; (4) Triassic shales in Stokes and Rockingham Counties; and (5) Triassic shales in Durham, Lee, Moore, and Anson Counties. With the exception of the Hot Springs area, deposits in other areas listed have been developed extensively.

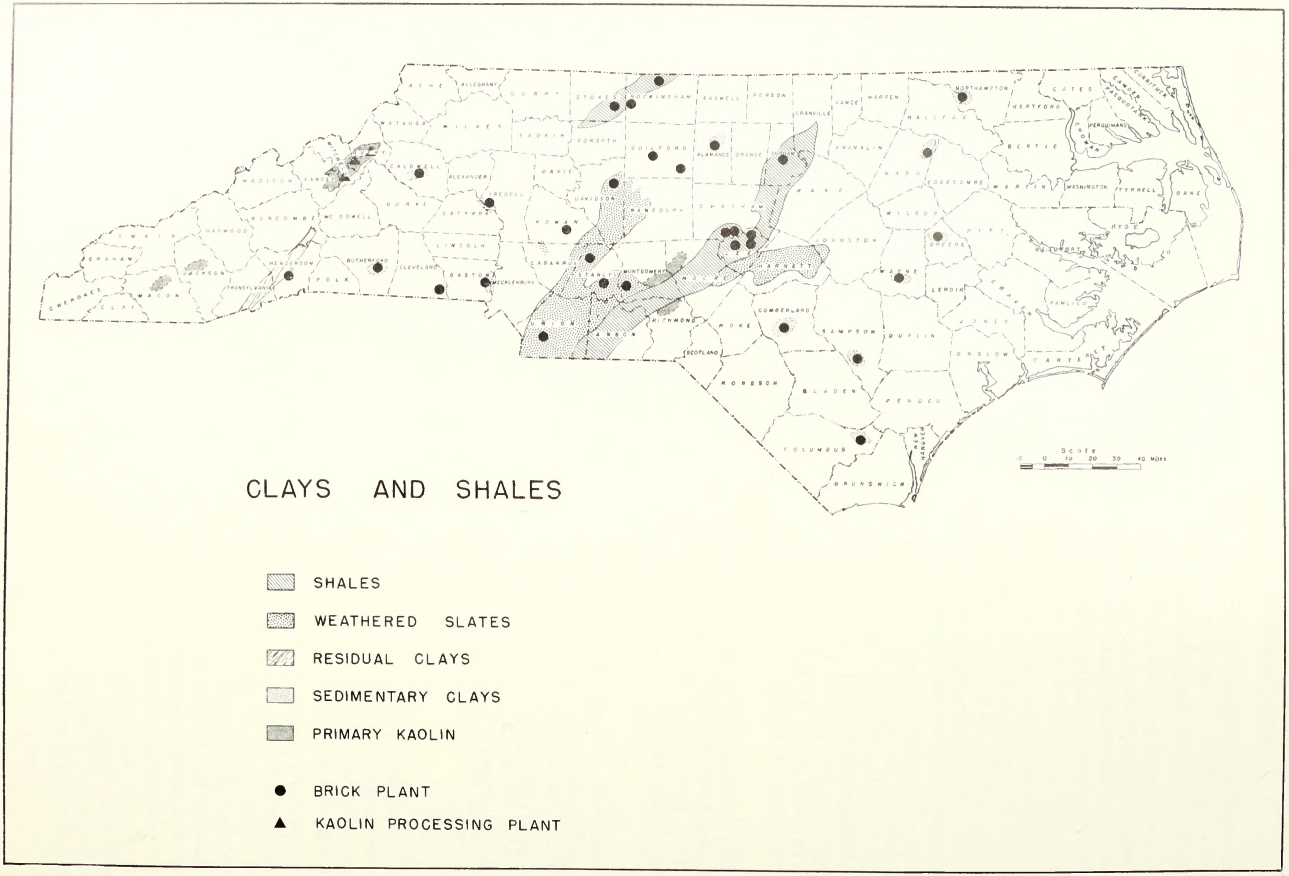

Figure 8. Clays and Shales.

During the period 1946-1953 North Carolina ranked eighth in the volume of structural clays produced in the United States and was first in the Southeast. Production rose steadily from approximately 500,000 tons in 1945 to more than 1,400,000 tons in 1953, and the value per ton for the corresponding years rose from approximately \$0.94 to \$1.17. Most of the clay mined was used by the producer for the manufacture of various structural products.

PRINCIPAL PRODUCERS OF STRUCTURAL CLAYS IN NORTH CAROLINA, 1953

Company	*Address*	*County*
Bennett Brick and Tile Company	Kings Mountain	Cleveland
Borden Brick and Tile Company	Durham	Durham
	Sanford	Lee
Boren Clay Products, Inc.	Pleasant Garden	Guilford
	Gulf	Chatham
Bostic Brick Company	Bostic	Rutherford
Chatham Brick and Tile Co., Inc.	Gulf	Chatham
Crumpler Brick Company	Roseboro	Sampson
Cunningham Brick Company	Thomasville	Davidson
Eastern Brick and Tile Company	Greenville	Beaufort
Grant Brick Works	Weldon	Northampton
Hanford Brick Company, Inc.	Burlington	Alamance
Ideal Brick Company	Fayetteville	Cumberland
Isenhour Brick and Tile Company	Salisbury	Rowan
Kendrick Brick and Tile Company, Inc.	Monroe	Union
	Mt. Holly	Gaston
Lee Brick and Tile Co., Inc.	Sanford	Lee
Moland-Drysdale Corp.	Hendersonville	Henderson
Moore Bros. Brick Company	Lenoir	Caldwell
Mt. Gilead Brick Company	Mt. Gilead	Montgomery
Nash Brick Company, Inc.	Rocky Mount	Nash
Norwood Brick Company, Inc.	Lillington	Harnett
Pine Hall Brick and Pipe Co., Inc.	Winston-Salem	Stokes
	Madison	Rockingham
Pomona Terra Cotta Company	Pomona	Chatham
Roanoke-Webster Brick Co., Inc.	Draper	Rockingham
Roger Moore Brick and Tile Co.	Wilmington	Columbus
Sanford Brick and Tile Company, Inc.	Colon	Lee
Sampson Brick Company	Roseboro	Sampson
Senter Brick Company	Lillington	Harnett
Stanly Shale Products, Inc.	Norwood	Stanly
Statesville Brick Company	Statesville	Iredell
	Statesville	Rowan
Yadkin Brick Yards, Inc.	New London	Stanly

Kaolin: The kaolins are a group of clay minerals which have the same chemical formula ($Al_2O_3.2SiO_2$-$2H_2O$) but differ in crystalline structures. Commercial kaolins are composed of one or more of these minerals and varying amounts of impurities. In the North Carolina deposits, kaolinite and halloysite are the most abundant of the clay minerals. Because of its use in making chinaware, kaolin is often referred to as china clay.

Kaolins form by the weathering of other mineral particles, especially feldspar. There are two principal types of deposits: (1) residual, formed by the decomposition of the rocks in place, and (2) sedimentary, the kaolin being transported from its original source and deposited in water. Although small deposits of sedimentary kaolin occur in North Carolina, the known economically valuable ones are of residual type.

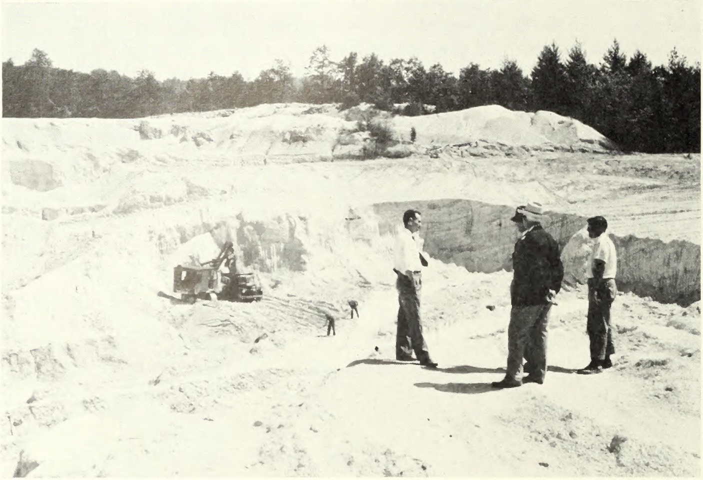

FIGURE 9. PRIMARY KAOLIN PIT NEAR SPRUCE PINE.

The kaolins of North Carolina are limited in occurrence to the Piedmont and Mountain areas of the stat While deposits are widespread in the Piedmont Plateau, they are generally small, and production has bee negligible. The commercially important occurrences are in the Mountain area, most of the production ha ing come from the Franklin-Sylva district, which embraces parts of Haywood, Jackson, Macon, and Swa Counties, and from the Spruce Pine district of Avery, Mitchell, and Yancey Counties. Although of a hi purity, deposits in the Franklin-Sylva district are limited in occurrence, having formed by the weatheri of pegmatites. Those in the Spruce Pine district were derived from the much larger alaskite bodies and no represent most of the known reserves in the state.

North Carolina has for years led in the production of primary or residual kaolin. Early production re ords are incomplete although the deposits were known by 1767, when T. Griffiths was sent from England what is now Macon County to obtain clay for Josiah Wedgewood. The first systematic mining was begun nea Webster, Jackson County, in 1888, and since that time kaolin has been produced in substantial quantities North Carolina. Most of the deposits in the Franklin-Sylva district have been worked out, and the total pr duction of the state is from the Spruce Pine district. Reserves of crude clay are estimated at 51 million to or in excess of 100 years' supply at the current rate of production.

ANALYSES OF WASHED KAOLINS FROM SPRUCE PINE, NORTH CAROLINA

	Sample 1	*Sample 2*
SiO_2	47.94%	46.18%
Al_2O_3	37.02	38.38
Fe_2O_3	0.60	0.57
TiO_2	0.02	0.04
CaO	0.30	0.37
MgO	0.07	0.42
K_2O	1.25	0.58
Na_2O	0.06	0.10
Zr_2O_3		0.08
Ignition Loss	13.03	13.28
Total	100.29	100.00

Raw kaolin as mined in the Spruce Pine district is a mixture of clay, quartz, small flakes of muscovite mica, and minor amounts of weathered garnet and biotite. The amount of recoverable clay from these deposits seldom exceeds 20 percent. Mining is by power shovels, and the kaolin is trucked to plants for processing. At the plants, most of the impurities are removed, the final product being kaolin and finely divided particles of mica and quartz. (Flake kaolin is produced as a byproduct in the refining operation.) North Carolina refined kaolin, when properly blended, equals the best of the imported clays.

The residual kaolins from North Carolina are of excellent quality. They are used in making china, porcelains and semiporcelains, spark plugs, glass melting pots, mosaic and other tile, and for many other uses. The price per ton ranges from about $20.00 to $22.50 (1953).

During the period 1946-1953, there were two producers in North Carolina. The Carolina China Clay Company mined kaolin near Penland until 1946, when operations ceased. Harris Clay Company, the only producer since 1946, owns and operates several mines in the Spruce Pine district. As of 1953, three plants were n operation. The Sparks plant is located at Minpro, northwest of Spruce Pine, the Avery County plant (old Kaolin, Inc., or Kalmia plant) is just east of U. S.Highway 19-E and about 5 miles northeast of Spruce Pine, the Gusher Knob plant in Avery County is 5.5 miles northeast of Spruce Pine and 0.5 of a mile from Ingalls. The old Lundy plant near Kona in Yancey County was closed in 1947, and a new plant was opened t Gusher Knob about 1952.

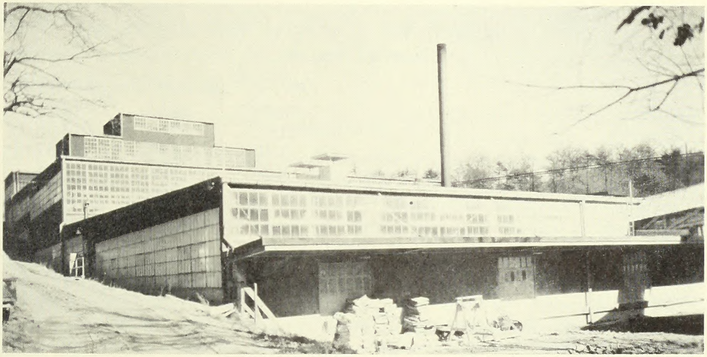

FIGURE 10. KAOLIN PROCESSING PLANT, AVERY COUNTY, NORTH CAROLINA

Halloysite: Halloysite, a clay mineral of the kaolin group, is a hydrated silicate of aluminum, containing 3.5 percent silica, 36.9 percent alumina, and 16.9 percent water. It is very white and is similar to kaolinite n general appearance and physical properties but is superior for certain ceramic uses.

Halloysite forms by the weathering of feldspar as does kaolinite, and the two minerals are associated in ccurrence. The highest grade haalloysite occurs in weathered portions of the more massive feldspar-type egmatites, and material of commercial grade is found in some of the alaskite formations. Most of the known eposits of economic importance are in the Spruce Pine and Franklin-Sylva districts and near Alexander n Buncombe County. The commercial kaolins produced in North Carolina are mixtures of halloysite and aolinite. Halloysite must be mined selectively in most cases and commands a higher price than kaolin.

ANALYSES OF HALLOYSITE FROM NORTH CAROLINA

Location	SiO_2	R_2O_3	Fe_2O_3	K_2O	Na_2O	Ign. Loss	Total
rrowood, Buncombe Co.	47.3	37.9	0.25	0.13	0.90	13.8	100.0
lexander, Buncombe Co.	45.0	39.9	0.29	0.46		14.7	100.1
arter Ridge, Mitchell Co.	44.8	41.2	0.18	0.34		13.9	100.2
reen Mountain, Yancey Co.	45.7	40.0	0.27	0.40		14.0	100.1
usher Knob, Avery Co.	49.6	37.0	0.27	1.06	0.48	12.3	100.4
icaville, Yancey Co.	47.0	38.9	0.11	0.22		13.8	99.9

The first recorded production of halloysite in North Carolina was by the Victor Mica Company in 194 and the clay was obtained from the Brushy Creek or Carter Ridge deposit, about 2 miles south of Spruce Pin This and the Arrowood deposit in Buncombe County were later worked by the Spruce Pine Mining Compan In 1944, Harris Clay Company began mining on the J. R. Sluder farm near Alexander in Buncombe Count continuing the operation until 1946. This company is producing a clay with a high-halloysite content fro the Gusher Knob deposit in Avery County, 5.5 miles northeast of Spruce Pine. As of December 1953, Harr Clay Company was the only producer of halloysite in the state.

During the latter half of 1948, geologists of the Tennessee Valley Authority, cooperating with the Nor Carolina Department of Conservation and Development, made a geologic investigation of the halloysite occu rences in Western North Carolina. Results of this investigation, published as Bulletin 58 of the North Car lina Department of Conservation and Development, showed an estimated reserve of approximately 200,0 tons in the area studied. Of this, 100,000 tons are associated with alaskite-type formations. Five of t principal deposits are estimated to contain between 28,000 and 36,000 tons of recoverable halloysite.

Other Clays: Small deposits of white-to-tan kaolinitic clays occur along the eastern Piedmont region the state, especially in Richmond, Montgomery, Moore, Harnett, Wake, Johnston, and Nash Counties. T clays are derived from very fine-grained rocks of the Volcanic-Slate series. The chief impurities are ir oxides and finely divided quartz, with occasional sulphides. Most of the clay will pass through a 200-mes screen.

ANALYSES OF RESIDUAL VOLCANIC CLAYS, RICHMOND COUNTY, NORTH CAROLINA

	Sample 1	*Sample 2*	*Sample 3*
Silica	70.63	68.15	73.70
Alumina	21.81	19.99	16.03
Ferric Oxide	1.49	1.86	1.57
Lime	0.20	0.13	0.38
Magnesia	0.29	0.16	0.47
Alkalies	1.45	2.85	1.90
Ign. Loss	4.04	4.70	4.33

These clays have been known for many years and some attempts have been made to mine them. Duri the early part of the century, clay was mined on a small scale near Ellerbe, Richmond County, and used pri cipally in cotton and paper goods. Deposits were prospected in Moore County about 1940 and a small amou of the clay was produced for the filler trade; and in 1950 and 1951, attempts were made to use some of t clay from near Candor in the manufacture of buff-colored brick and tile. During the summer of 1950, t Department of Conservation and Development investigated these resources and collected samples for firi tests carried out at North Carolina State College. Results of these studies are published as Informati Circular 8 of the North Carolina Department of Conservation and Development and Bulletin 49 of the Nor Carolina State College School of Engineering. The white residual clays of the Volcanic-Slate series do n occur in sufficient volume to be considered a major clay resource, but they offer possibilities for limit uses.

*CLAY SOLD AND USED IN NORTH CAROLINA FROM 1945 TO 1954

Year	*Short tons*	*Value*	*Value per ton*
1945	525,506	$ 783,220	$1.49
1946	914,999	1,178,030	1.29
1947	1,068,572	1,314,976	1.29
1948	1,204,747	1,436,417	1.11
1949	1,181,047	1,335,954	1.13
1950	1,437,202	1,766,785	1.23
1951	1,462,030	2,177,515	1.49
1952	1,357,700	2,080,172	1.54
1953	1,466,232	2,534,232	1.72
Average 1945-1953	1,179,722	1,623,033	1.37

*Includes kaolin and halloysite

Clay Production in North Carolina: During the period 1945-1953, clay production in North Carolina expanded rapidly. More than 90 percent of the clay mined was used in the manufacture of heavy clay products. Kaolin and halloysite production was strong throughout the period but showed no great fluctuation in volume.

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FELDSPAR

Feldspar is a general term applied to a group af aluminum-silicate minerals containing varying propor-ions of potash, soda, and lime. There are three principal varieties: the potash feldspars, microcline and rthoclase; the soda feldspar, albite; and the soda-lime or plagioclase group of feldspars. All have similar hysical properties, differing principally in chemical composition and ceramic properties. Commercial feld-pars usually are intergrowths of one or more varieties.

The feldspars are important raw materials in the ceramic industries, and over 97 percent of the domestic onsumption of ground feldspar is used by the glass, pottery, and enamel industries. In 1953, glass accounted or 55 percent; pottery, 39 percent; enamel, 3 percent, and the remaining 3 percent was consumed by various ndustries, including soaps and abrasives. In general, commercial grades of feldspar relatively high in soda-me and low in iron are used in glass making, while those having a high potash-to-soda ratio are desirable or pottery. Feldspars used for glazing must contain 4 percent or more of soda.

In North Carolina, there are two principal occurrences of economically important feldspar. One is a ma-or constituent of pegmatite dikes which are quite common in the Mountain and western Piedmont regions f the state. The other is as a part of coarse-textured granitic rocks, called alaskite, which underlie a con-iderable portion of the Spruce Pine district of Avery, Mitchell, and Yancey Counties and have been found in arts of Buncombe and Jackson Counties. Such rocks contain about 40 percent plagioclase feldspar, 20 per-ent microcline, 30 percent quartz, and 10 to 20 percent mica. Ferromagnesian minerals are present, but in mall quantities. In general, feldspars from pegmatites are relatively high in potash content and are most esirable for use in pottery. Feldspars derived from alaskite contain considerable amounts of the soda-lime arieties and are used principally in glass making; however, by the addition of small amounts of potash par, they can be made to meet other class specifications.

Reports indicate that feldspar was shipped from North Carolina to England as early as 1744, but the first nportant production was in 1911, when a carload was mined and shipped from Mitchell County. This mark-d the beginning of the present feldspar industry, and since 1917 North Carolina has been the major source f domestic feldspar. Most of the production has been centered around the Spruce Pine district and the ryson City area, but important tonnages have come from Haywood, Jackson, Macon, and Transylvania ounties. Although there has been no production recorded, interesting deposits occur in western Lincoln ounty.

During the early days of the industry, feldspar was produced entirely from pegmatites, but by 1940 mu of the more accessible material had been removed and shortages were anticipated. Extensive research feldspar technology during the late 1930's and early 1940's resulted in the development of a froth flotati process by which feldspar could be separated from other minerals economically. This process, well adapt to the alaskite type of ore, revolutionized the feldspar industry in North Carolina. In 1945, the first co mercial froth flotation plant for the recovery of feldspar was constructed by the Carolina Minerals Compa

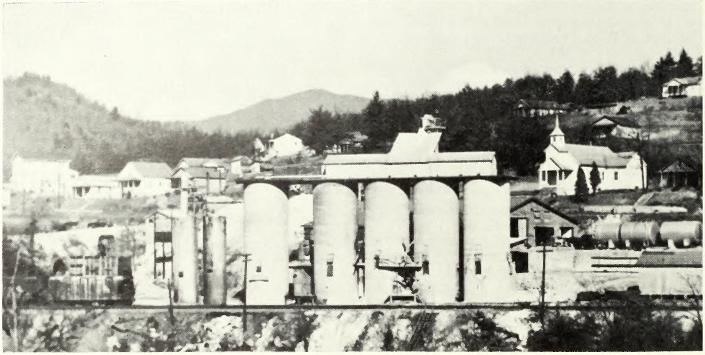

FIG. 11. FELDSPAR FLOTATION PLANT, SPRUCE PINE

a subsidiary of the Consolidated Feldspar Corporation, at Kona, in Mitchell County. By 1948, Feldsp Flotation Corporation had completed its plant at Spruce Pine, and in 1950 Carolina Mineral Company erect its second flotation plant near Spruce Pine. Although a considerable amount of high-grade feldspar is s obtained from pegmatites, the bulk of North Carolina's production is the "flotation spar" recovered fr alaskite.

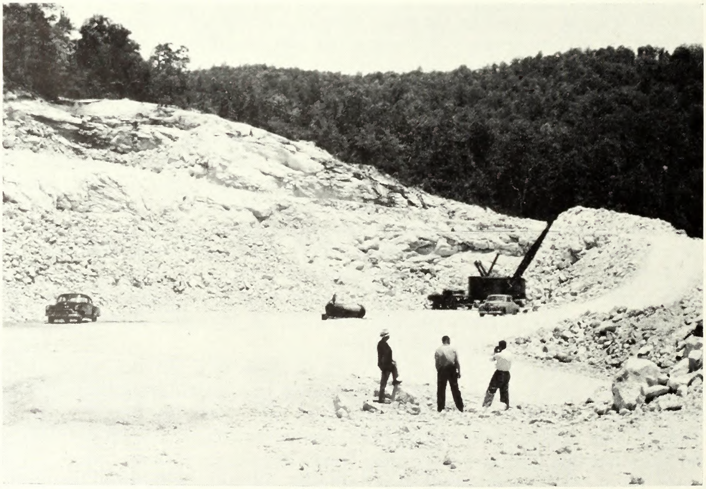

FIGURE 12. ALASKITE QUARRY NEAR SPRUCE PINE

Within the past few years the feldspar industry has changed from a group of unorganized grinders and agon miners to a highly efficient well knit organization. Modern methods and closely controlled processes ake North Carolina's feldspar industry the most important in the United States. Most of the operating mpanies mine and process the crude ore, but a considerable amount of feldspar is purchased by the mills om individual miners.

Mining is by open cut or quarry methods, there being few underground operations. Because of the na- re of the deposits, mines in pegmatite bodies are usually small, and the high-grade block feldspar must be nd-sorted prior to being sold to the grinders. Such operations are often seasonal, and a large or steady roduction is difficult to maintain. Alaskite deposits, however, are mined on a large scale, quarries several ndred feet wide and as much as a hundred feet high having been developed. Crude feldspar, both from peg- atites and alaskites, is trucked to plants for processing. High-grade pegmatite feldspar from the Bryson ity area is hauled to Spruce Pine, a distance of about 135 miles.

During the period 1946-1953, the average annual production of crude feldspar in North Carolina amounted 208,981 long tons, valued at $1,527,300.00. This is an increase of 123 percent in volume and 188 percent value over the previous 10 years, and represents 48 percent of the volume and 52 percent of the value of erage annual production in the United States for the period under consideration. The price per ton rose om $4.35 in 1946 to $12.28 in 1953, averaging $7.07 as compared with $5.63 for the 1936-1945 period.

Crude Feldspar Produced in North Carolina and the United States from 1945 through 1953

	North Carolina		United States	
Year	Long Tons	Value	Long Tons	Value
1945	148,493	$ 863,740	373,054	$2,021,529
1946	230,367	1,002,638	508,380	2,594,099
1947	220,997	1,081,514	459,910	2,410,940
1948	201,774	1,116,825	460,713	2,564,387
1949	160,916	973,431	369,378	2,278,441
1950	183,027	1,107,061	407,925	2,558,390
1951	166,361	1,230,404	400,439	2,815,587
1952	240,364	2,416,031	420,831	3,696,018
1953	268,042	3,290,495	452,600	4,594,450

Principal Producers of Crude Feldspar in North Carolina during 1953

Producer	*Address*	*Mine Location (County)*
ue Ridge Mining Co.	Burnsville	Buncombe, Jackson Swain, Mitchell
one Brothers	Spruce Pine	Mitchell
ifton Buchanan and Co.	Spruce Pine	Mitchell
inton Gardner	Micaville	Yancey
n Honeycutt		Yancey
er Park Mines, Inc.	Spruce Pine	Mitchell
ldspar Flotation Corp.	Spruce Pine	Mitchell
ldspar Producing Co.	Erwin, Tenn.	Avery, Mitchell, Yancey
nley and Westall	Nebo	Yancey
pp Mining Co.	Spruce Pine	Mitchell
ternational Minerals and Chemical Corporation	Kona, Spruce Pine	Mitchell
hnny Gouge	Toecane	Yancey
hn C. Woody	Green Mountain	Yancey
cil Grindstaff	Bakersville	Mitchell
arson and Pitman	Spruce Pine	Mitchell
y Cook	Burnsville	Mitchell
y Grindstaff	Bakersville	Mitchell
y M. Pitman	Spruce Pine	Mitchell
eve Sparks Mining Co.	Spruce Pine	Mitchell
aits Pitman	Spruce Pine	Avery
ll Gouge	Spruce Pine	Mitchell

Crude feldspar mined from pegmatites is delivered to processing plants, where it is blended and grou specifications. High-potash varieties are sometimes blended with "flotation spar" to meet special ma requirements. Alaskite is shipped to flotation plants, where it is ground to approximately 20-mesh anc feldspar separated from the associated minerals. Mica and quartz are byproducts of the operation.

For the years 1946-1953, the average annual production of ground feldspar sold by processing plan North Carolina and Tennessee was 218,094 short tons, valued at $2,768,991.00. This represented 47 pe of the tonnage and 44 percent of the value of the average yearly production of ground feldspar sold by chant mills in the United States.

GROUND FELDSPAR SOLD BY MERCHANT MILLS IN NORTH CAROLINA-TENNESSEE AND IN THE UNITED STATES FROM 1945 THROUGH 1953

	*North Carolina-Tennessee**		*United States*	
Year	*Short Tons*	*Value*	*Short Tons*	*Value*
1945	142,208	$1,665,634	381,728	$4,246,961
1946	207,252	2,192,254	470,199	5,346,107
1947	217,109	2,360,352	482,700	5,861,141
1948	219,720	2,377,030	506,451	6,462,231
1949	159,768	2,203,604	386,707	5,609,101
1950	200,373	2,526,268	446,523	6,343,619
1951	197,704	2,886,655	454,615	6,932,878
1952	270,775	3,714,084	458,920	6,712,481
1953	272,059	3,891,684	463,876	7,148,689

*Figures include production of grinding plant at Erwin, Tennessee, which uses North Carolina feldspar.

PRODUCERS OF GROUND FELDSPAR IN NORTH CAROLINA AND TENNESSEE FROM 1946 THROUGH 1953

Company	*Plant Location*
Feldspar Flotation Corporation	Spruce Pine
Feldspar Milling Company	Bowditch
North Carolina Feldspar Corp.	Erwin, Tenn.
International Minerals and Chem. Corp.	Kona
(Consolidated Feldspar Div.)	Erwin, Tenn.
Interstate Feldspar Corp.	Dillsboro
United Feldspar and Minerals Corp.	Spruce Pine

Some of the more outstanding events in the feldspar industry from 1946 through 1953 were:

1. Perfection of flotation process and the erection of the first flotation plant late in 1945, and the s quent construction of additional plants in 1948 and 1950.
2. Basic research and the development of personnel skilled in feldspar technology by the North Car State College Minerals Research Laboratory in Asheville. This laboratory played an important in establishing and improving feldspar flotation procedures in North Carolina.
3. Geologic mapping of the Spruce Pine and Bryson City districts. This work was carried out by the U ed States Geological Survey as part of a cooperative program by that agency and the Division of Mi Resources of the North Carolina Department of Conservation and Development.
4. In 1952, the feldspar grinding plant of the United Feldspar and Minerals Company at Spruce Pine lost by fire. The company did not rebuild.
5. During 1953, the International Minerals and Chemical Corp. acquired control of Consolidated Feld Corporation, which operated flotation plants and mines in Mitchell County.

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GEMS AND PRECIOUS STONES

North Carolina is noted for the many varieties of gems and precious stones found within its borders. mong the more outstanding are varieties of quartz, opal, beryl, corundum, spodumene, garnet, rutile, kyan- e, zircon, epidote, tourmaline, and diamond. Others include staurolite, spinel, peridot, lazulite, and serpen- ne. Gems have been found in widely separated areas throughout the Piedmont and Mountain regions of he state, especially in parts of Alexander, Burke, Clay, Cleveland, Iredell, Jackson, Macon, Mitchell, Tran- lvania, Warren, and Yancey Counties. For many years North Carolina has been a small producer of gems nd precious stones, but records are incomplete and many of the stones found have not been recorded. Most f the discoveries have been accidental, and although some interesting deposits have been found, few proved be profitable mining ventures.

Mining for gems in North Carolina had its beginning in the finding of rolled crystals in gold-mine wash- gs, some of which were of gem quality. Later, mica mines were developed, in which were found beryl, arnet, and other minerals. The first systematic mining was undertaken by C. W. Jenks in 1871, when he ened a mine for gem corundum at Corundum Hill in Macon County. A short time later, a mine was open- l along Buck Creek in Clay County. Neither mine proved to be profitable, and both were closed after rela- vely short periods of operation. Later, the Corundum Hill Mine was a major producer of abrasive-grade rundum, and some gem varieties were recovered during the operation. W. E. Hidden opened the first nerald mine in North Carolina at Stony Point in Alexander County, about 1880, and small amounts of nerald and the associated gem variety of spodumene, hiddenite, were produced for several years. An nerald-bearing pegmatite was discovered on Crabtree Mountain, Mitchell County, in 1894 and was mined for short period. In 1895, systematic mining was started to recover rubies from gravels in the Cowee Valley ea of Macon County. A considerable number of stones were recovered, but many of them were of poor ality. About the same time, rhodolite garnet was discovered in the area, and quite a number of gems were und. Since those early beginnings, gems and precious stones have continued to be found in North Carolna d various attempts made to mine the better known deposits; however, where sytematic mining has been tempted, most of the operations were short-lived.

Diamonds: Thirteen authentic diamonds have been found in North Carolina. Most of these have come om McDowell, Burke, Rutherford, Lincoln, Mecklenburg, and Franklin Counties. The first was found ar Brindletown, Burke County in 1843 and was valued at $100.00. The last recorded find was near Kings ountain, Cleveland County, in 1893. Most of the stones average less than 2 carats, the largest recorded om North Carolina weighing 4.33 carats. It was discovered in 1886 near Dysartsville, McDowell County.

Rubies and Sapphires: These are the more familiar gem varieties of corundum. In North Carolina, they ve been found principally in Jackson, Macon, Clay, and Transylvania Counties. Two of the more impor- nt localities from which rubies and sapphires have been produced are Corundum Hill and the Cowee Valley ea of Macon County. Good quality sapphires have been found at the Sapphire Corundum Mine, Jackson unty, and Montvale, Transylvania County. Ruby corundum occurs at a number of localities in Clay, Tran- lvania, and Buncombe Counties. Some of the better stones have come from Corundum Hill.

Emerald: Emerald is a clear and transparent form of beryl and is among the more valuable of precious nes. Although small amounts have been found at a number of localities, the more important occurrences e at Stony Point, Alexander County, and Crabtree Mountain near Spruce Pine, Mitchell County. Interest- g specimens have been found in Cleveland County.

Other Beryl Gems: Excellent quality aquamarines have been obtained from the Littlefield Mine on Tessen- e Creek and the McGee Mine in Macon County; from the Wiseman Mine near Flatrock, and the Grassy eek area near Estatoe in Mitchell County; and at the Ray Mine in Yancey County. Yellow and golden ryl occur in Alexander, Burke, Mitchell, and Yancey Counties.

Hiddenite, Kunzite: These minerals are gem varieties of spodumene. Hiddenite, the green variety, was scovered at Stony Point, Alexander County, during emerald-mining operations and was mined for several ars. Kunzite, a pink spodumene, has been found in small quantities in a pegmatite near Spruce Pine, Mit- ell County.

Quartz: Quartz furnishes many of the common gem stones and is found in many colors and forms. Cai gorn stone (smoky quartz), amethyst, citrine topaz, and rock crystal are among the more important varieti found in North Carolina. Sagenite or Venus Hairstone, a crystal quartz enclosing hair-like crystals of rut is found in Alexander and Iredell Counties. Amethyst and other quartz gems are found in Alexander, I dell, Macon, Catawba, Burke, Randolph, Lincoln, Ashe, and Warren Counties.

There are many other gems and precious stones found in North Carolina. Those, such as staurolite, spi peridot, lazulite, and serpentine, are quite common minerals, and only the rare, clear and transparent vai ties which are free from flaws are considered to be of value.

During the period 1946-1953, there is no recorded production of gems from North Carolina, but undou edly some were found. Dealers in North Carolina gem materials are, as follows:

Linten B. Greene	Spruce Pine, N. C.
Roby Buchanan	Hawk, N. C.
Fred O. Scroggs	Brasstown, N. C.
Dewey Moose	Stony Point, N. C.

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GRAPHITE

Graphite, also known as black lead and plumbago, is one of the crystalline varieties of elemental carb It is a very soft, black, greasy feeling mineral which occurs as disseminated flakes or in scaly or comp earthy masses. When impure, it is often slaty or earthy. Graphite is used in making crucibles, founc facings, lubricants, pencils, crayons, paint, stove polish, commutator brushes, and for many other uses.

Graphite has been found at many localities within the area of crystalline rocks in the central and weste parts of North Carolina. It is most commonly associated with gneisses, schists, and metamorphosed lir stones but also occurs in pegmatites and other intrusive formations. Some of the better known occurren are in Alexander, Catawba, Cleveland, Macon, McDowell, Rutherford, Wake, and Yancey Counties. Vario attempts have been made to produce graphite commercially in North Carolina, but most of the operatio were short-lived. The last production was from Graphiteville, in western McDowell County, but this ope tion ceased in 1916 when a flood damaged the mill.

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HIGH-ALUMINA MINERALS

Included in this classification are minerals which have many properties in common and are among t more important used for high-temperature refractory purposes. Those occurring in North Carolina a andalusite, kyanite, sillimanite, topaz, and diaspore. which as a group average more than 65 percent alumi With the exception of diaspore, all are aluminum silicates. They are unstable above 1545° C. and disassoci to form mullite ($3Al_2O_3.2Sio_2$) and silica. Mullite, stable up to 1810° C., is an important superduty refra tory. Diaspore is a hydrous aluminum oxide which looses its water of crystallization upon heating, the resu ing alumina melting between 1880° C. and 2050° C.

The production of mullite from andalusite, kyanite, sillimanite, and topaz accounts largely for the usef ness of these minerals in the ceramic industries. Mullite imparts to ceramic products such highly desira properties as high refractoriness, low thermal expansion with resultant resistance to heat shock, interme iate thermal conductivity, high load-bearing ability even at high temperatures, and resistance to chemi corrosion, particularly acid slags. Diaspore's importance is in its great refractoriness.

Economic deposits of andalusite, topaz, and diaspore are relatively rare, but interesting occurrences a found in rocks of the Volcanic-Slate series in the central Piedmont region of the state. These minerals occ

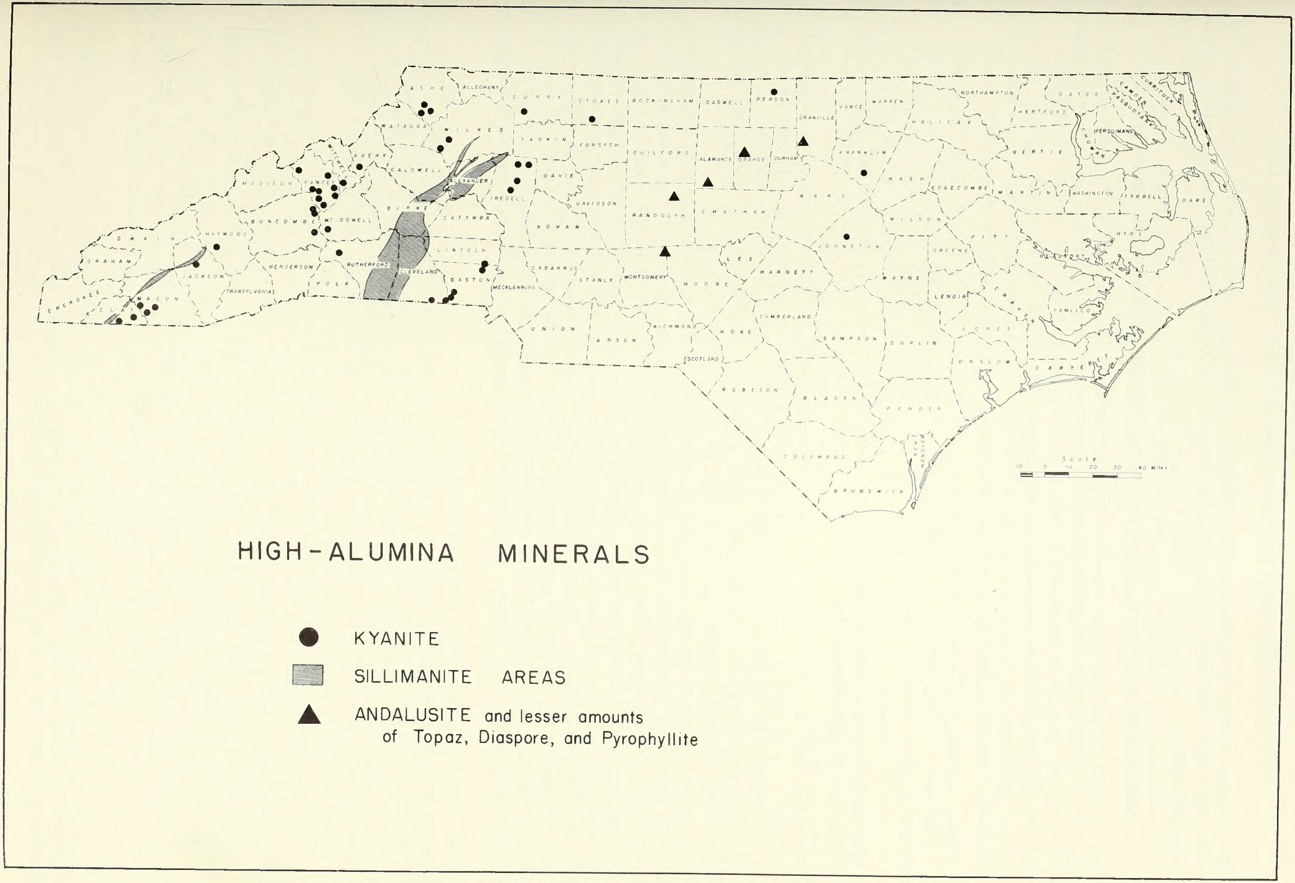

FIGURE 13. HIGH-ALUMINA MINERALS

in the same deposits and are associated with pyrophyllite and sericite. Because of their occurrence they are described here as a unit. Deposits of kyanite and sillimanite are found locally in many of the crystalline rock areas of the state.

ANDALUSITE, MASSIVE TOPAZ, AND DIASPARE ASSOCIATED WITH PYROPHYLLITE

Andalusite (Al_2SiO_5) has the same chemical composition as sillimanite and kyanite, all containing 63.2 percent alumina. It occurs as well defined prismatic crystals or in rough columnar, or granular masses. The mineral has a specific gravity of between 3.16 and 3.20 and is stable to between 1350° C. and 1380° C. Commercial deposits are rare, the most important in the United States being in California. Among the more important uses of andalusite are in spark plug insulators, expansion sleeves, pyrometer tubes, glass-house refractories, electric furnace refractories, mill linings, extrusion dies, laboratory ware and other products.

Massive topaz has the general formula $[Al_2(F.OH)]_2SiO_4$ in which the hydroxyl radical often replaces the fluorine. Analyses of several samples show the mineral to contain about 56 percent alumina, 33 percent silica, and 14 percent fluorine. It has a specific gravity of from 3.4 to 3.6. Upon heating to between 1000° C. and 1400° C. the volatile elements are driven off, leaving a mixture of mullite and silica. Among the possible uses of topaz are in the steel industry as a substitute for fluorite, in the preparation of leadless glazes, as a glass opacifier, and in high-temperature furnaces.

Diaspore ($Al_2O_3.H_2O$) is a hydrous aluminum oxide containing 85.1 percent alumina. It is relatively stable to between 1880° C. and 2050° C., its melting range. The mineral occurs as thin flattened prisms, foliated masses, or thin scales. Its specific gravity ranges from 3.3 to 3.5. The only known commercial deposits consists of an earthy or granular form of diaspore. Most of the diaspore produced is used in the manufacture of refractory brick, although a small amount is used for abrasive purposes.

Within the past few years, sizable quantities of andalusite and lesser amounts of topaz, diaspore, kyanite, and sillimanite have been identified in the massive-type pyrophyllite deposits in the east-central portion of the Piedmont region of the state. Such deposits are found only in rocks of the Volcanic-Slate series, in which they occur as replacement-type bodies. Most are somewhat lenticular in outline and consist principally of pyrophyllite, sericite, and quartz, the high-alumina group of minerals often constituting less than 10 percent of the minerals present. Andalusite is perhaps the most abundant of the high-alumina group, although concentrations vary widely between deposits. All are in various stages of replacement by pyrophyllite and sericite, a condition which complicates their economic recovery. Several of the deposits are being worked as pyrophyllite mines, the mine product being a combination of pyrophyllite and associated high-alumina minerals.

The better known occurrences in North Carolina are:

1. Bowlings Mountain, located in Granville County, 2.75 miles west of the village of Stem. This deposit is more than 1000 feet long and as much as 500 feet wide. Massive topaz is most abundant along the southeastern side of the deposit. The principal mineralized zone consists of andalusite, pyrophyllite, sericite, kyanite, sillimanite, and minor amounts of topaz and diaspore. From 1950 through 1954, this deposit was explored in detail by the Carolina Pyrophyllite Company. The company plans to develop the property as soon as concentration problems are worked out.
2. The Hillsboro deposit is immediately southeast of Hillsboro, Orange County. It is approximately 1000 feet long and has a width which varies from 20 to as much as 200 feet. The principal high-alumina mineral is andalusite, which in places constitutes as much as 75 percent of the rock. Pyrophyllite and sericite are common. This deposit was prospected by North State Pyrophyllite Company in 1951, and quarrying began on a small scale about 1952. The ore is being blended and used for refractory purposes.
3. The Staley Mine is one of the oldest and largest of the massive-type pyrophyllite mines. It is located in Randolph County, 3.5 miles west of Staley and 4.5 miles southwest of Liberty. The mine has been active for more than 25 years. The deposit is about 350 feet long and 250 feet wide. Although pyrophyllite has replaced much of the high-alumina mineral content, considerable amounts of andalusite and some diaspore are present. The mine is operated by Carolina Pyrophyllite Company, which conducted detailed drilling and exploration programs between 1950 and 1953.
4. The Snow Camp deposit is in Alamance County 3.5 miles southeast of the village of Snow Camp. It is about 350 feet long and 250 feet wide and has been worked since 1936 by North State Pyrophyllite Company. The ore consists of a mixture of pyrophyllite, andalusite, and lesser amounts of other high-alumina minerals. It is used for refractory purposes.

There are several small deposits scattered throughout the Volcanic-Slate series, but reserves are small in most cases. Kyanite occurs as a replacement mineral on Hagers Mountain, Person County; kyanite and pyrophyllite are present in a quartzose rock on the Corbitt property, 5 miles north of Smithfield, Johnston County; andalusite and diaspore have been reported from the Comer-Aumen deposit in northeastern Montgomery County and the Hinshaw property in western Moore County.

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KYANITE

Kyanite, like other members of the sillimanite group of minerals, is an aluminum silicate ($Al_2O_3.SiO_2$), containing 63.2 percent alumina and 36.8 percent silica. Upon heating, kyanite will increase in volume approximately 16 percent and will disassociate to form mullite and silica at or below 1545° C. Kyanite usually occurs in long-bladed, flat crystals or fibrous masses and sometimes as radiating aggregates of crystals. It is a common constituent of many metamorphic rocks and pegmatites.

The uses of kyanite include in the manufacture of glass, porcelain, refractory brick, spark plugs, electrical and chemical porcelains and chinaware, enamelware, and hotelware. Refractories utilizing raw materials of the sillimanite group of minerals are glass-house refractories, various furnaces, high-temperature cements, combustion tunnels, and cement kiln linings.

Kyanite is quite widespread in metamorphic rocks of the Piedmont and Mountain areas of North Carolina. It occurs (1) as disseminated crystals in gneiss or schist, (2) as lenses in pegmatite dikes, (3) irregularly distributed throughout quartzose masses and veins, and (4) in residual clay formed by the weathering of kyanitic gneiss. One of the important kyanite areas in North Carolina is a zone from 6 to 8 miles wide, which extends from near Burnsville in Yancey County to Swannanoa, Buncombe County. The kyanite occurs in a biotite gneiss and schist, which in places has been injected with granitic materials. Kyanitic gneisses and schists occur in several parts of Clay and Macon Counties, in Wake County and other areas in the Piedmont. Kyanite has been found in several quartz veins and pegmatites in the Spruce Pine district, especially near Black Mountain, Buncombe County. Other interesting deposits are associated with quartzitic masses in the Piedmont area. Among those are occurrences near Kings Mountain, Cleveland County; Chubb Mountain, Gaston County; east of Lake Lure, Rutherford County; Hagers Mountain, Person County; and 5 miles east of Clayton along U. S. Highway 70, Johnston County. Tests were made on samples from some of the deposits. The tabulation below shows the kyanite content of the samples and chemical analyses of froth flotation products.*

Location	*Percent Kyanite*	*Kyanite Concentrates*		
		% Al_2O_3	*% Fe_2O_3*	*% TiO_2*
Celo Mtn.	13.5	61.4	0.6	Tr.
Lake Lure	25.0	60.7	0.8	Tr.
Chubb Mtn.	44.5	58.0	1.3	....
Johnston Co.	27.6	61.8	0.3	0.26

*Testwork performed by North Carolina State College Minerals Research Laboratory.

Although some attempts have been made to mine kyanite in North Carolina, the only appreciable production has come from Little Celo Mountain, 4 miles south of Burnsville, Yancey County. The deposit is somewhat lenticular in outline, is about 250 feet wide and 2000 feet long, and consists of a biotite mica gneiss averaging from about 12 percent to 20 percent kyanite. It was developed by both open-quarry and underground mining. Production started in 1936 and continued intermittently until 1944. There has been no production from the property since that time. Prior to World War II, several carloads of high-grade kyanite were shipped from near Black Mountain, but a lack of reserves caused the operation to cease.

During the period 1945-1953 there was no recorded production of kyanite in North Carolina. The North Carolina Department of Conservation and Development mapped and sampled several deposits in the Piedmont region, and preliminary beneficiation tests were carried out by the North Carolina State College Minerals Research Laboratory in Asheville. As a part of their regional studies of the kyanite resources in Southeastern United States, the United States Geological Survey mapped the larger kyanite occurrences in Nor Carolina. Although there has been no kyanite mined in the state since Celo Mines, Incorporated, closed i operations in 1944, several of the more promising deposits in the quartzitic rocks have been investigated l various companies, most of the prospecting having been done in the Kings Mountain and Chubb Mounta areas.

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SILLIMANITE

Sillimanite is an aluminum silicate and, like andalusite and kyanite, has the general formula Al_2O_3.Si It is generally gray, brown, yellowish, or greenish and occurs as long, thin, needlelike crystals or in radiatin fibrous or columnar masses. When heated above 1650° C. sillimanite expands approximately 6.5 percent a is converted into a stable mixture of mullite ($3Al_2O_3.2SiO_2$) and vitreous silica.

Sillimanite has not as yet been produced in commercial quantities in the United States. Research has de onstrated that the mineral is potentially an important refractory and has possible uses in porcelains, hig alumina refractory brick, crucibles, saggers, high-temperature cements and furnace linings, pyrometer tub and in many other refractory and ceramic products.

In North Carolina, the principal occurrences of sillimanite are in highly fractured argillaceous and quart itic rocks, which in many cases have been altered by granitic intrusives. Deposits are erratic and appear be confined to major zones of shear. The most common rock type is a quartz-biotite schist, which has be highly sericitized locally. Sillimanite occurs as needlelike crystals disseminated throughout the schist or elliptical-shaped bundles of crystals in the schist. It constitutes from less than 1 to more than 30 perce of the rock, averaging about 12 percent in the better deposits. The sillimanite readily alters to sericite, a such altered material is present in most of the occurrences. Other minerals present include kyanite, stau lite, garnet, graphite, chlorite, zircon, pyrite, ilmenite, rutile, sericite, and barite, with minor quantities tourmaline, sphene, clinozoisite, and chromite.

There are two principal sillimanite-bearing zones in North Carolina: the Cliffside-Elkin belt in the upp Piedmont region and the Warne-Sylva belt in the southwestern Mountain area. The Cliffside-Elkin belt occ pies a zone extending from the South Carolina line northeastward through parts of Rutherford, Clevela Burke, Lincoln, Caldwell, Catawba, Alexander, Iredell, and Wilkes Counties. The more outstanding depos are those at Smith Cliff, 7 miles southeast of Morganton, Burke County; Cages Mountain, 6 miles southw of Hudson, Caldwell County; Dudley Shoals deposits, 4.5 miles northeast of Granite Falls, Caldwell Count and Fox's Orchard deposit in Iredell County, 8 miles northeast of Hiddenite. The largest known reserves the state are concentrated in the Cliffside-Elkin belt, although a considerable amount of the sillimanite partially sericitized. The Warne-Sylva belt extends from the Georgia line northeastward across Clay a Macon Counties to the vicinity of Sylva in Jackson County. The more important deposits are in the Bra town-Cherry Mountain area of Clay County, North Carolina, and Towns County, Georgia; the Hayesvi area, especially along Hyatt Mill and Downing Creeks in Clay County; the Etna Cowee area in Mac County, especially the occurrences near Saldeer Gap, Oak Grove, and Leatherman; the Greens Creek area Macon County; and the Sylva area of Jackson County.

Sillimanite has been known in North Carolina since 1873, but major occurrences were not found until 19 when Charles E. Hunter, geologist with the Tennessee Valley Authority, discovered extensive deposits of limanite-bearing schists near Valdese, Burke County. In 1945, Hunter and White made a reconnaissa study of the area, results of which were published as Information Circular 4 of the North Carolina Depa ment of Conservation and Development. In 1949, the North Carolina Department of Conservation and velopment, North Carolina State College Minerals Research Laboratory, and the Tennessee Valley Author carried out a cooperative program of detailed investigation of the known occurrences of sillimanite in the st and made preliminary concentration tests of the higher grade material. Results of this study were publi ed as Bulletin 61 of the Department of Conservation and Development. Research on some of the concentrates produced was carried out at North Carolina State College in Raleigh and Clemson College, Clemson, South Carolina. Although large deposits of sillimanite are known in North Carolina, a considerable amount of work must be done to perfect a process by which sillimanite in various stages of alteration can be concentrated economically.

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LIGHTWEIGHT AGGREGATE

Lightweight aggregate is the aggregate used in the manufacture of cinder blocks and other lightweight precast masonry units. It has been defined as "an aggregation of fine and coarse particles of a material which because of its light weight, strength, low absorption, and chemical stability can be mixed with cement to form a concrete of predetermined characteristics." Although lightweight concretes were used in some large buildings and residential units prior to 1945, they were not well accepted by the trades until the great construction boom which followed World War II. During this period they were used widely in residential and small nonresidential buildings in which they were found desirable for production of prefabricated large-size masonry units. Lightweight concretes are now used in the manufacture of precast units, including masonry and back-up blocks, bricks, floor beams, columns and partitions, roofs, and floor tiles and slabs. For many years the aggregate used in lightweight concretes was industrial cinders. However, the rapidly expanding use of concrete material and a decrease in the volume of available cinders caused by many industries switching from coal to other fuels have caused a shortage of byproduct lightweight aggregate. This condition resulted in the large-scale manufacture of suitable aggregate from clays and shales.

There are two distinct types of lightweight aggregate prepared from clays and shales, a sintered product and an expanded or bloated product. In sintering, the raw material is finely ground, mixed with pulverized fuel, pelletized, and placed on a traveling grate which carries it to an ignition chamber. Here the disseminated fuel is rapidly burned out of the mixture, leaving a lightweight product. The sintering process is advantageous over the bloating process in certain areas, since it can be adapted to a greater variety of raw materials. Expanded or bloated lightweight aggregate is prepared by heating certain types of clay, shale, or slate in a rotary kiln. Gasses released from the raw material when in the pyroplastic condition cause it to expand into a lightweight product having a cellular structure. A good bloating material must have suitable minerals present which will disassociate at moderate temperatures to form the necessary gas, and these minerals must be finely disseminated throughout the material so that a uniform structure will result.

In North Carolina there are many clays and shales which are potential sources of lightweight aggregate. Residual clays are widespread in the Piedmont region and can be sintered to make suitable aggregate, but none of this type appears satisfactory as bloating clay. The Rome shale near Hot Springs, Madison County, the black Triassic shales in Stokes, Rockingham, Lee, and Chatham Counties, and the Paleozoic slates in Stanly and Davidson Counties have bloating characteristics.

In 1946 the North Carolina Department of Conservation and Development, North Carolina State College Minerals Research Laboratory, and Tennessee Valley Authority began a series of studies of potential raw materials for the manufacture of lightweight aggregate. In 1949, the Department of Engineering Research of North Carolina State College made sintering tests on various raw materials in the state and did considerable research on the development of a fired, lightweight unit. The first lightweight aggregate plant in North Carolina was erected in 1949, near China Grove, Rowan County. This plant, operated by the Tuff-Lite Corporation of Salisbury, produces aggregate from a residual clay by sintering. Tests of raw materials for this plant were carried out by Sintering Machinery Company of Netcong, New Jersey.

During 1947 and 1948, Southern Lightweight Aggregate Corporation of Richmond, Virginia, investigated the Triassic shales in Stokes and Rockingham Counties as possible boating shales. Results of these studies showed that although a lightweight product could be obtained, its lack of uniformity made it undesirable as a raw material. M. R. Jackson inspected many materials throughout North Carolina and adjacent states in an attempt to find a suitable bloating shale, but abandoned the project. In 1951, the Southern Lightweight Aggregate Corporation began extensive studies of the slates in North Carolina and in 1953 erected a plant near Aquadale in southern Stanly County. This plant, operated by the Carolina Solite Company, utilizes a bloating process and produces a good-quality aggregate. Both the sintered and bloated aggregates are used widely throughout the state.

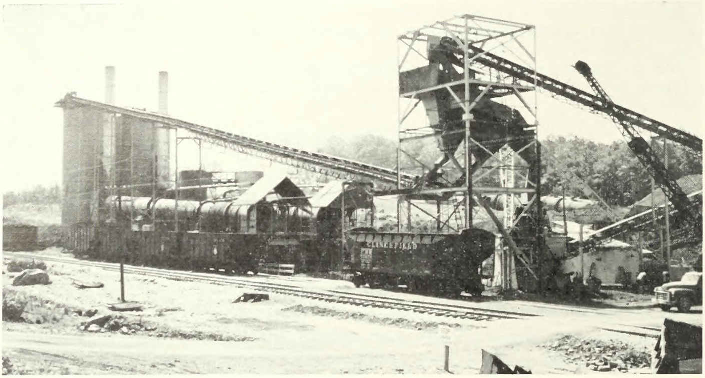

FIGURE 14. LIGHTWEIGHT AGGREGATE PLANT NEAR AQUADALE, STANLY COUNTY. AGGREGATE IS PRODUCED FROM SLATE BY BLOATING PROCESS.

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LITHIUM

Lithium is the lightest of all metals, having a specific gravity of only 0.534. It is one of the alkali metals and is very active chemically. Although discovered as early as 1817, its industrial application developed very slowly until World War II, when it emerged rapidly as one of the outstanding industrial mineral products. Since that time it has been in considerable demand.

The uses of lithium are many. As a metal, it is used for the degasification and deoxidization of high-conductivity copper and other nonferrous metals, and in the grain refinement of nodular iron in ferrous metallurgy. It is reported to be a source of the hydrogen isotope tritium (H^3) used in the thermonuclear bomb Lithium alloys of magnesium, aluminum, copper, lead, and zinc are being developed; however, it is in compounds that lithium has its widest industrial application. Lithium stearate, used in the preparation of greases, coating compositions, and waxes, accounts for nearly half of the domestic consumption. A major use of chemicals and ores of lithium is in glass, porcelain enamel, glazes, glass enamels, and other ceramic products. Lithium salts are used widely in the pharmaceutical trade, the hydroxide in alkaline storage batteries, the chloride and bromide in air-conditioning and dehumidifying units, the borate in dental cream, the nitrite for curing meat, the chloride and fluoride in welding fluxes, the hydroxide for mercerizing sulphite cellulose for rayon, and for purifying helium and other rare gasses. Lithium amide is used in the manufacture of antihistamines. Small amounts of lithium compounds are used for pyrotechnical purposes. Lithium carbonate is used in greater quantity than any other lithium compound and is the material from which lithium and other lithium chemicals are made.

Commercial sources of lithium are rare and are confined usually to pegmatite or veinlike occurrences. Spodumene, lepidolite, and amblygonite are the important ore minerals. Spodumene, $LiAlSi_2O_6$, is the most important and is produced principally in North Carolina and South Dakota. Lepidolite, $LiKAl_2F_2Si_3O_9$, a lithium mica, is mined in South Dakota, New Mexico, and California. One occurrence is known in North Carolina. Amblygonite, $IiAl(SiO_3)_2$, is produced in California and South Dakota. Considerable amounts of dilithium sodium phosphate are recovered from the brines at Searles Lake in California. Other lithium minerals include triphylite, petalite, and zinnwaldite. Amblygonite, lepidolite, and petalite are imported from Africa.

The largest known reserves of spodumene in the western hemisphere are in North Carolina. Hiddenite, a rare emerald-green variety, occurs in pegmatites near the village of Hiddenite in Alexander County and has been mined on a small scale for gem-quality material. Kunzite, a rare lilac-to-pink variety, has been found in small quantities near Spruce Pine. The economically important spodumene is a light green to white variety which occurs in the central Piedmont region of the state. A series of spodumene-bearing pegmatites form a belt nearly 25 miles long and 2 miles wide, which extends southwestward from Lincolnton, Lincoln County, to Grover, Cleveland County. Within this belt, there are more than 700 pegmatites, one foot or more in width, which average approximately 15 percent spodumene and carry small amounts of beryl, tin, and columbite. There are two areas of major importance. One is southwest of Kings Mountain, where the largest dikes are exposed; the other is the Beaverdam Creek area south of Lincolnton, where a great many smaller pegmatites crop out. The spodumene occurs as lathlike crystals from less than an inch to more than 3 feet in length and is associated principally with fine-grained albite and quartz. Other minerals include microcline, muscovite, cassiterite, beryl, columbite-tantalite, amblygonite, and apatite. As many as thirty minerals have been identified in the pegmatites.

T. L. Kesler, geologist with the United States Geological Survey, carried out the first detailed survey of the tin-spodumene-bearing pegmatites from 1938 until 1942 and estimated spodumene reserves in the Kings Mountain and Beaverdam Creek areas to be in excess of 650,000 tons within a depth of 100 feet. The United Feldspar and Minerals Company carried out beneficiation tests on the ore and marketed a mixture of feldspar and spodumene under the trade name of "Lithospar." Froth flotation tests were made on the ore by the United States Bureau of Mines. With a rapid demand for lithium brought on by World War II, the Solvay Process Company constructed a flotation plant near Kings Mountain for the recovery of spodumene. Production began on May 17, 1943, and lasted until February 1945, when government contracts were suspended. The drop in demand for lithium made further work uneconomical. The plant and properties were kept on a standby basis.

In 1950, Foote Mineral Company of Philadelphia leased the Solvay interests with option to buy and acquired additional properties. In January 1951, work began on renovating the mill and preparing the quarries, and production began July 29, 1951. The process used was developed in the North Carolina State College Minerals Research Laboratory, located at Asheville. By the summer of 1953, construction, designed to increase the plant capacity from 360 tons per day to more than 1000 tons per day, had started. The first recorded production of tin and columbite-tantalite concentrates as byproducts from the operation was in 1952. Research is being conducted to find methods for the economic recovery of beryl during the processing of spodumene.

Other companies carrying out investigations during the period 1946-1953 included Lithium Corporation of America, which made detailed studies of deposits in the Beaverdam Creek area and near Grover, south of Kings Mountain. Kaweckie Chemical Company prospected near the village of Crouse, and Consolidated Feldspar Corporation investigated dikes in the Long Creek Church area and lepidolite occurrences near Inez, Warren County. Exploratory drilling was conducted on the old Ka-Ma-Tin properties near Lincolnton.

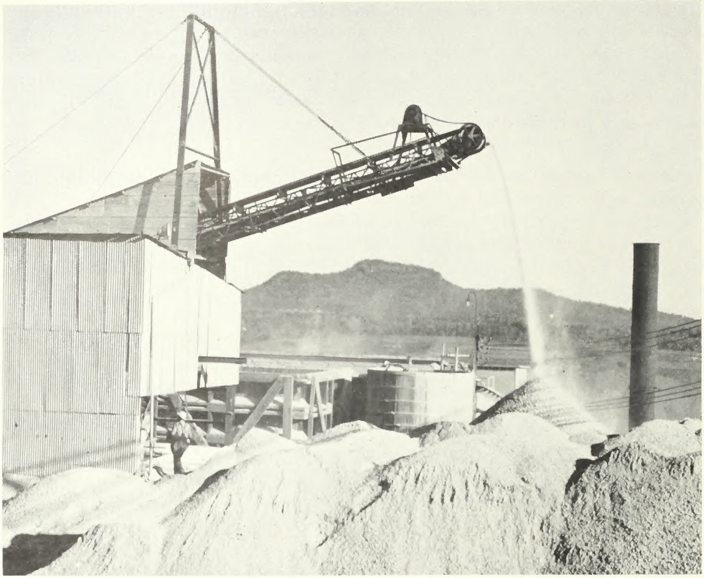

FIGURE 15. SPODUMENE CONCENTRATES PRODUCED NEAR KINGS MOUNTAIN
(Courtesy Foote Mineral Company)

Since there is a single producer of spodumene in North Carolina, production figures cannot be disclosed. However, since the opening of the plant of Foote Mineral Company at Kings Mountain, the volume of concentrates has continued to increase rapidly. A general trend of the growing importance of lithium and the rapidly expanding production in North Carolina is indicated in the production figures for the United States.

SHIPMENTS OF LITHIUM ORES AND COMPOUNDS FROM MINES IN THE UNITED STATES FROM 1947 THROUGH 1952.

Year	*Ore Short Tons*	*Value*	*Li_2O Short Tons*	*Year*	*Ore Short Tons*	*Value*	*Li_2O Short Tons*
1947	2,441	$ 151,113	199	1950	9,306	$ 579,922	747
1948	3,881	210,792	291	1951	12,897	896,000	956
1949	4,838	345,970	475	1952	15,611	1,052,000	1,088

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MICA

There are many varieties of mica, all of which are complex aluminum silicates containing one or more bases, such as potassium, sodium, magnesium, lithium, and iron. The most distinctive physical feature common to all true micas is the development of an almost perfect basal cleavage, permitting the mica to be split into very thin laminae. There are some seven different varieties of mica, four of which, muscovite, phlogophite, lepidolite, and biotite, are used widely by industry. Muscovite, the potash or white mica having the general formula $H_2KAl_3(SiO_4)_3$, is by far the most important commercial mica and is followed by phlogophite, the amber magnesian mica, $H_2KMg_3Al(SiO_4)_3$. Biotite, $H_2K(Mg,Fe)_3Al(SiO_4)_3$, is of limited importance, and lepidolite, $(OH,F)_2KLiAl_2Si_3O_{10}$, is of value as a source of lithium.

USES

Mica is consumed by industry in three principal forms: as clear sheets cut to specifications, as thin splittings, and as finely ground powders. The value of sheet mica, principally muscovite, is dependent largely upon clearness, size, color, and freedom from included particles, cracks, and holes. When processed, sheet mica and mica splittings are the most important accessory materials in the electric and electronic industries. High-grade sheet mica is used as the dielectric in capacitators for radio and radar circuits, magnetocapacitators, and coils. It is used as insulation in aircraft spark plugs and high-voltage lamps; in radio, radar, and television tubes; as high-pressure gauge glass gaskets; in special metal casting processes and as viewer plates in metallurgical furnaces. "Electric mica" is used in the manufacture of many electrical appliances, such as toasters, irons, coffee pots, and hot plates. "Built-up mica," formed by thin mica splittings bonded together to form sheets which can be cut to specifications, is used to make insulation products, such as mica cloth, tape, and mica plate. In 1953 approximately 68.6 percent of the sheet and film mica fabricated in the United States was for electronic purposes.

Scrap or flake mica is that unsuitable for sheet mica because of size or quality and is marketed in the ground form. Mica ground wet is used in the manufacture of wallpaper, paint, ornamental tile, and rubber goods. Dry-ground mica is used in the manufacture of roofing. Both types are used in molded insulation, surfacing asphalt shingles, Christmas tree snow, lubricants, plastic specialties, annealing, and for many other uses. Mica board, a specially prepared bonded ground mica, shows considerable promise.

THE MICA INDUSTRY IN THE UNITED STATES

The United States is the largest consumer of mica in the world and produces over 90 percent of the scrap or flake mica needed. However, approximately 97 percent of its requirements of strategic grades of sheet mica must be imported; therefore, in times of national crisis, the domestic supply of sheet mica becomes extremely important, and various economic steps must be taken to increase production. During World War II, domestic production accounted for about 12 percent of total consumption.

Mica has been produced from 23 states in the Union, but during recent years the principal sources of supply have been North Carolina, South Dakota, Colorado, Georgia, and the New England States. North Carolina accounts for approximately 79 percent of the total domestic production.

MICA IN NORTH CAROLINA

Varieties of mica found in North Carolina include muscovite, biotite, paragonite, lepidolite, and fuchsite. Of these, muscovite is the only one considered to be present in commercially workable amounts. Many grades of green, brown, amber, and ruby muscovite are present and have been produced in varying quantities.

Occurrence, Distribution, and Quality: Economic deposits of mica are confined to the narrow, somewhat tabular, veinlike bodies called pegmatites, and to the large masses of coarse-textured granitic rock referred to as alaskite. Although restricted in size, pegmatites are the sources of most of the high-grade sheet mica. These tabular bodies range from a few inches to more than a hundred feet in width and from a few to several hundred feet in length. The mica occurs in restricted zones or shoots. Alaskite is a coarse-textured granitic rock occurring as massive bodies up to several hundred feet in width. Mica books are generally small and are distributed throughout the rock. Alaskite is the principal source of scrap or flake mica.

The major producing areas in North Carolina are the Spruce Pine district, embracing Avery, Mitchell, and Yancey Counties; the Franklin-Sylva district, in Haywood, Jackson, and Macon Counties, and the Shelby district of Cleveland, Lincoln, and Gaston Counties. Mica has also been mined from many other localities in the State.

The Spruce Pine district is the principal source of mica in the state. Sheet mica is mined from the many pegmatites in the district, while most of the scrap is recovered from alaskite either by direct mining and concentrating or as a byproduct of kaolin and feldspar processing. Much of the sheet mica has a somewhat greenish hue, but considerable brown, amber, and rum-colored books are produced. From 70 percent to percent of the state's mica production is from the Spruce Pine district.

Mica from the Franklin-Sylva district ranges in color from rum to ruby and represents some of the highest quality material found in the state. Production is relatively small and is restricted to pegmatite occurrences, over 300 of which have been recorded. Much of the total volume of mica mined in this area, however, has been from a few of the larger pegmatites. It is estimated that approximately 20 percent of the mica produced in North Carolina is from the Franklin-Sylva district.

Pegmatites in the Shelby district yield high-grade sheet and scrap mica, most of which is pinkish-buff or cinnamon-brown muscovite. Some green varieties occur. The deposits in this district often are more highly kaolinized than those in the other districts and in many cases do not extend to as great depths. This district was an erratic producer until World War II, when after considerable exploration several important deposits were discovered. Since that time, it has become of increasing importance as a source of both sheet and scrap mica.

Mining and Preparation: Because of the size and attitude of pegmatites, most sheet mica mines are small and operators must resort to underground methods to recover the mica. Picks and shovels are used in the softer parts of the veins, while unweathered material must be blasted. Mica is separated from the gangue materials by hand and is carried to trimming houses, where it is sheeted and trimmed prior to being marketed. Much of the trimmed sheet is fabricated in North Carolina.

Scrap-mica deposits generally are much larger than sheet-mica pegmatites and are mined by hydraulic giants, tractor-pulled pans, or by power shovels and trucks. The crude material is hauled to washing plants where the kaolin, quartz, and other harmful substances are removed prior to delivery to local grinding plants. Scrap is also recovered in processing kaolin and as a byproduct of feldspar flotation. Flotation mica, having come from fresh hard rock, has a greater bulk density than mica from the kaolinized alaskite, and its present uses are restricted.

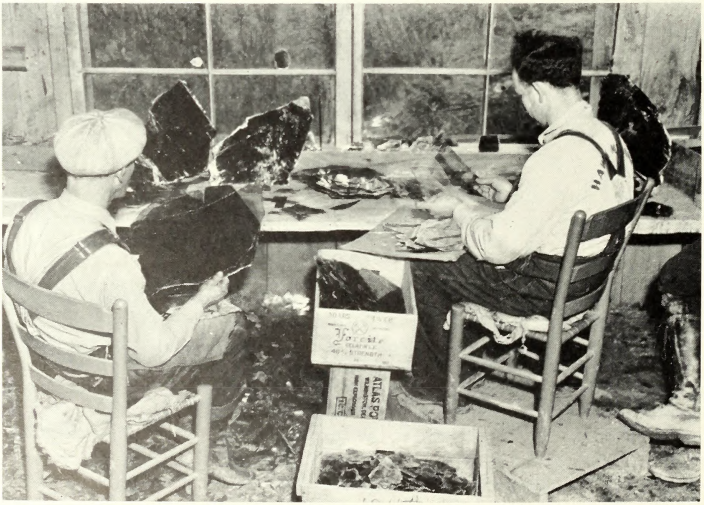

FIGURE 16. GRADING SHEET MICA

The Sheet Mica Industry: From 1945 through 1953, North Carolina continued to dominate the domestic ica field. Mica mining nearly ceased during the change from the regimented economy of World War II, arked by subsidized operations and fixed prices, to a peacetime economy, in which domestic mica had to ompete with readily available high-grade imports. It was rejuvenated in 1950 by a second subsidized proram, designed to aid in stockpiling strategic grades.

During World War II, the United States Government, through its agency Colonial Mica Corporation, was he sole buyer of domestic strategic mica. Prices were controlled and amounted to as much as $8 per pound. arious green, brown, and amber micas were accepted readily, and the sheet-mica industry flourished in orth Carolina. On January 1, 1945, following a decrease in demand for mica, Colonial Mica Corporation estricted its purchases of mica to that of ruby quality. Because the bulk of the mica in North Carolina is ot ruby in color, it did not meet specifications. On Noverber 30, 1945, all government restrictions were liftd, and the domestic sheet-mica industry had to compete with cheap imports. As a result, mica mining in orth Carolina declined rapidly and by 1947 production was the lowest recorded since 1933. Following ternational problems involving foreign mica supplies and in anticipation of a new subsidy program, the omestic production of sheet mica began to increase.

In order to encourage discovery and development of strategic and critical minerals, the United States Govrnment created the Defense Minerals Administration (DMA), an agency through which financial assistance uld be obtained by members of the mining industry for purposes of exploration and development. This gency, later known as the Defense Minerals Exploration Administration (DMEA), was established in 1950. y the end of 1953, it had executed 104 mica exploration contracts in North Carolina, which amounted to 571,336.00. Of this amount, the United States Government furnished $514,229.40. In March 1952, Genal Services Administration announced its plans to purchase domestic sheet mica at prices ranging from $3 $70 per pound, depending upon grade. This agency erected a mica-purchasing depot in Spruce Pine and gan buying mica and other strategic minerals in July 1952. Although not reaching the volume produced uring World War II, the sheet-mica industry in North Carolina has continued to expand at a steady rate. he production since 1932 is tabulated below.

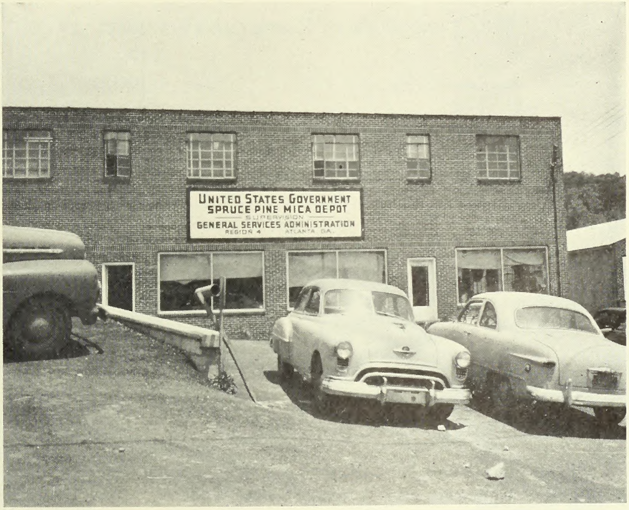

FIG. 17. U S. GOVERNMENT MICA-PURCHASING DEPOT, SPRUCE PINE.

RECORDED PRODUCTION OF SHEET MICA FROM NORTH CAROLINA, 1932-1953

Year	*Pounds*	*Value*	*Year*	*Pounds*	*Valu*
1932	127,696	$ 18,322	1943	1,901,120	$1,772,3
1933	162,672	21,107	1944	814,874	1,530,6
1934	293,381	38,674	1945	563,990	243,0
1935	512,590	77,598	1946	424,791	135,5
1936	730,446	119,653	1947	210,816	84,2
1937	1,044,328	218,176	1948	257,926	44,6
1938	632,646	87,879	1949	507,935	113,0
1939	401,170	69,344	1950	483,736	102,1
1940	1,002,646	218,154	1951	464,948	127,2
1941	1,614,863	318,783	1952	595,331	664,0
1942	1,654,895	505,634	1953	619,895	1,308,4

During the period 1945-1953, the average annual production of sheet mica from North Carolina was 44 672 pounds, valued at $322,433.00. This represents 41 percent by weight and 63 percent by value of the p duction for the previous ten-year period. From 1946 through 1951, the average value of all sheet and pur mica from North Carolina was $0.27 per pound, although prices ranged from 12 to 22 cents for punch a from $0.75 to $6 for sheet, depending upon size and grade. In 1952 the average price per pound of sh and punch mica produced in North Carolina had risen to $1.12; in 1953, it was $2.11 per pound. This crease in overall value resulted from government purchases, which in 1953 amounted to 96,438 pounds, v ued at an average of $12.07 per pound.

MICA FABRICATORS IN NORTH CAROLINA, 1952

Company	*Address*	*Product*
Asheville Mica Co.	Biltmore	Punched, Built-u Fabricated
Carpenter & Phillips	Spruce Pine	Fabricated
Farnham Mfg. Co.	Asheville	Fabricated
F & K Mica Co.	Spruce Pine	Fabricated
H. A. Knight	High Point	Fabricated
Spruce Pine Mica Co.	Spruce Pine	Fabricated
Tar Heel Mica Co.	Plumtree	Built-up Fabricated

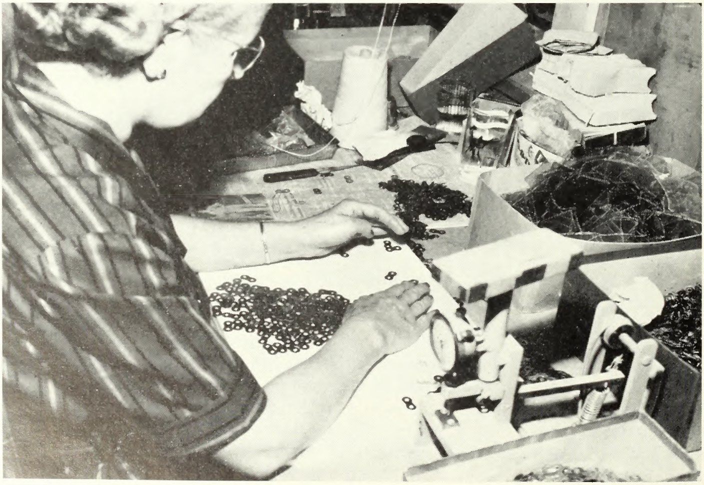

FIGURE 18. FABRICATING SHEET MICA, SPRUCE PINE.

Scrap and Ground Mica: Scrap is a term generally applied to all mica which is, because of size, color, or ality, below specifications for sheet mica and which can be processed satisfactorily for industrial use as ound mica. In most cases it refers to the muscovite variety. From 70 percent to more than 90 percent of e mica in most deposits is of scrap grade. In North Carolina, scrap mica is obtained as waste from sheet-ica mining, trimming, and fabricating; as a byproduct of kaolin and feldspar flotation, and mined directly om large well kaolinized alaskite and pegmatite bodies containing high contents of fine mica. Approxi-ately 75 percent of that produced in North Carolina is obtained from so called "scrap mica deposits." Re-lts of a survey carried out in 1947 and 1950 by the North Carolina Department of Conservation and De-lopment and Tennessee Valley Authority indicates reserves of mineable scrap-mica ore to be in excess of ,000,000 tons. Mica from this source is separated from gangue material in washing plants prior to being ld, while waste mica from the sheet-mica industry does not require cleaning.

PRINCIPAL PRODUCERS OF SCRAP MICA IN NORTH CAROLINA, 1952

Producer	*Address*	*County*
rolina Mica Co.	Kingsport, Tenn.	Yancey
nsolidated Mica Co.	Asheville	Mitchell
weld Mica Co.	Spruce Pine	Mitchell
glish Mica Co.	Spruce Pine	Mitchell
ed Arnold	Franklin	Macon
ed Deneen Mica Co.	Newdale	Yancey
ssett Mining Co.	Burnsville	Yancey
ngs Mountain Mica Co.	Kings Mountain	Cleveland
acon Mica Co.	Franklin	Macon
ca Mining Co.	Asheville	Yancey
ca Products Corp.	Franklin	Macon
naqua Mica Co.	Asheville	Yancey
wdale Mica Co.	Newdale	Yancey
n-Metallic Minerals, Inc.	Franklin	Jackson, Macon
uthern Mica Co.	Johnston City, Tenn.	Mitchell
ilson Mica Co.	Spruce Pine	Mitchell

PRODUCERS OF MICA FROM KAOLIN AND FELDSPAR PROCESSING IN NORTH CAROLINA IN 1953

Producer	*Plant Location*	*Source*
ldspar Flotation Corp.	Spruce Pine	Feldspar Flotation
rris Clay Company	Spruce Pine	Kaolin Processing
ternational Minerals and Chemical Corp.	Kona, Spruce Pine	Feldspar Flotation

Scrap mica is manufactured by being ground to a powder meeting certain size, color, and bulk-density ecifications. Two basic processes are used in reducing the scrap, namely, wet grinding and dry grinding. e first is rather expensive and is employed where a product having great reflective properties and consid-able slip is required. Only the highest grades of scrap muscovite are used. The second process, dry inding, reduces mica rapidly and inexpensively and produces a rather dull powder having very little of the een of wet ground mica. The bulk of North Carolina scrap mica is dry ground. Within recent years there ve been several improvements in grinding equipment, and some grades of mica prepared by wet grinding, ncipally a batch process, can be produced in a continuous process.

Approximately 90 percent of the mica consumed by grinders in the United States is of domestic origin. Of s amount, North Carolina furnishes about 75 percent. Most of the production is muscovite, the bulk of ich is from the Spruce Pine district. However, important amounts are mined and processed from near ngs Mountain, Cleveland County, and Franklin, Macon County. A chlorite schist is ground at Spruce Pine l sold as biotite.

PRODUCERS OF GROUND MICA IN NORTH CAROLINA DURING 1953.

Company	*Location*	*Product*
Asheville Mica Co.	Biltmore	Dry Ground
Deneen Mica Co.	Newdale	Dry Ground
Deweld Mica Co.	Spruce Pine	Dry Ground
Diamond Mica Co.	Spruce Pine	Wet Ground
English Mica Co.	Spruce Pine	Wet Ground
Franklin Minerals Product Corp.	Franklin	Wet Ground
Harris Clay Company	Spruce Pine	Dry Ground
International Minerals and Chemical Corp.	Newdale	Dry Ground
Tarheel Mica Co.	Plumtree	Wet Ground

Although the production of crude scrap dropped sharply in 1945 following World War II, the indus recovered rapidly, and during the period covered by this report broke all previous production records. Fr 1946 through 1953 the average annual production was 45,264 tons of crude scrap, valued at $1,019,875, $22.53 per ton. This represents an increase in tonnage of 155 percent and in value of 210 percent when co pared with the previous ten years. As of 1950, scrap mica was produced in North Carolina directly from concentrating plants, as a byproduct from 3 kaolin recovery plants and 3 feldspar flotation plants, and fr many sheet mica operations. It was processed by 6 wet-grinding plants and 5 dry-grinding plants operat within the state. In 1953, mica ground in North Carolina and sold to consumers amounted to 40,051 sh tons, valued at $2,143,766, averaging $53.52 per ton. Market quotations listed by E & MJ Metal and Mine Markets for December 24, 1953, quotes the price of North Carolina wet ground mica at from $140 to $ per ton; dry ground, from $32.50 to $70 per ton; and scrap, from $32 to $35 per ton.

SCRAP MICA PRODUCED IN NORTH CAROLINA, 1925-1953

Year	*Short Tons*	*Value*	*Value/Ton*
1925	7,095	$ 124,818	$17.59
26	5,314	124,048	23.34
27	5,409	113,670	21.01
28	8,739	132,119	15.12
29	8,346	153,722	18.42
1930	5,904	97,600	16.53
31	6,872	84,818	12.34
32	6,237	71,842	11.52
33	8,968	102,830	11.47
34	7,255	101,985	14.06
1935	11,831	153,553	12.98
36	10.840	131,138	12.10
37	12,988	209,212	16.11
38	11,959	161,598	13.51
39	13,913	184,377	13.25
1940	11,595	173,327	14.95
41	18,234	268,596	14.73
42	24,145	485,560	20.11
43	25,295	516,637	20.41
44	29,775	750,285	25.20
1945	30,682	709,334	23.12
46	39,100	887,901	22.78
47	38,655	844,086	21.83
48	44,428	992,303	20.80
49	24,801	640,374	25.85
1950	48,193	1,281,000	26.58
51	52,550	1,441,886	27.44
52	58,576	1,551,071	26.48
53	55,184	1,520,381	27.51

Research and Field Investigations: From 1945 through 1953, several significant investigations were m which were of interest to the mica industry. Of special value to the producers of sheet mica were the stu carried out cooperatively by the North Carolina Department of Conservation and Development, Tenne alley Authority, and United States Geological Survey from July 1945 through April 1946. This was an in- stigation to determine if possible a correlation between physical properties of mica and commercial classi- ations then in use, especially the color classification. A total of 2,502 different lots of mica, containing 7,764 pieces were tested by the Bell Telephone Laboratories' "Q-Meter," also known as Type 130-A Mica est Set. The mica represented over 850 deposits throughout the Southeastern States. Results of these sts, published in Professional Paper 225 of the United States Geological Survey, show that no relation ists between color and quality of mica and that mica from North Carolina and other Southeastern States is ual and in some cases superior to Bengal (India) ruby mica, the standard used in commercial classifi- tion.

Information obtained from detailed studies of the sheet-mica deposits in the Piedmont of North Carolina as published as Professional Papers 248-A, B, C, and D of the United States Geological Survey. Pegmatites the Cashiers and Zirconia districts were studied by geologist of the United States Geological Survey in 48 and the results published as Bulletin 64 of the North Carolina Department of Conservation and De- lopment.

A detailed survey of the scrap-mica deposits in North Carolina, made in 1947 and 1950 by the North Caro- a Department of Conservation and Development and the Tennessee Valley Authority, indicated a reserve over 31,000,000 tons of ore. Bulletin 66 of the North Carolina Department of Conservation and Develop- ent summarizes this work.

A significant advance was made in mica grinding by staff members of the North Carolina State College inerals Research Laboratory. A continuous mica grinder was developed which produced ground mica com- rable in many respects to the high-grade, wet-ground mica produced by a slow, batch process. Industrial search perfected methods for reducing mica to fine sizes by use of superheated high-pressure steam and air.

The use of Humphrey Spirals in the recovery of flake or scrap mica was developed by the North Carolina ate College Minerals Research Laboratory and proved highly successful. Spirals have now been installed r the recovery of mica at several mica concentrating and kaolin processing plants. This equipment accounts r the recovery of fine mica which had been heretofore lost, which in some cases amounted to over 50 per- nt of the total mica content of an ore. Its successful utilization has doubled recoverable reserves of scrap ca in North Carolina.

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OLIVINE

Olivine is a magnesium silicate, having the general formula $(Mg,Fe)SiO_4$. It is olive green to dark yel- wish-green and occurs as irregularly outlined crystals and as small grains. Analyses of typical olivines ow a magnesia content of about 48 percent and a silica content of approximately 40.5 percent. Olivine is ommon constituent of many basic rocks and forms a major part of peridotite intrusives, in which it is often sociated with nickel and chromite. Dunite, a nearly pure olivine rock having chromite or picotite as acces- y minerals, is the most abundant of the peridotites in North Carolina.

Olivine is used principally as refractory bricks, shapes, and high-temperature cements. It is used to a ser extent as foundry sands and as a source of magnesium salts and is a potential source of magnesium tal, various compounds, and special fertilizers.. Olivine is marketed as crude blocks or in the ground form.

The largest reserves of olivine in the eastern part of the United States are in Western North Carolina a Northern Georgia. Although more than 275 deposits are known to occur, many are in advanced stages steatization and serpentization and are considered of limited value as sources of olivine. In a detailed surv carried out by the Tennessee Valley Authority in 1940, it was estimated that reserves of high-grade olivi in 20 of the more accessible deposits amounted to 230,000,000 tons, which average 48.07 percent magnes and more than a billion tons of partially altered dunite, composed of 50 percent or more olivine which av ages 44 percent magnesia.

The localities in which principal deposits occur are centered around Frank, Avery County; Toecane, Ya cey County; Canton and Democrat, Haywood and Buncombe Counties; Balsam, Addie, and Webster, Jac son County; Ellijay, Macon County; and Buck Creek and Shooting Creek, Clay County. The Webster-B sam area contains the largest reserves in the state, four of the principal deposits containing 448,000,0 tons of readily mineable material.

PRINCIPAL PRODUCERS OF OLIVINE IN NORTH CAROLINA, 1945-1953

Name	*Address*	*Deposit*	*County*
Harbinson Walker Refractory Company	Pittsburgh, Pa.	Addie	Jackson
United Feldspar and Minerals Company	Spruce Pine	Day Book	Yancey
Olivine Products Corp.	Sylva	Webster	Jackson
Carolina Magnovine Corp.	Waynesville	Balsam Gap	Jackson
Ray Wiseman	Green Mountain	Day Book	Yancey

Production of olivine for industrial uses in the United States began in North Carolina in 1930, and sin that time the state has been a small but steady producer. The average annual production from 1945 throu 1953 was approximately 5,375 short tons, which represents more than 90 percent of the total domestic pr duction. The price per ton rose from $11.50 in 1946 to $20 in 1953.

PRODUCTION OF OLIVINE IN NORTH CAROLINA AND IN THE UNITED STATES, 1946-1951

Year	*North Carolina Short Tons*	*United States Short Tons*
1946	6,249	7,649
1947	7,938	10,838
1948	4,766	4,766
1949	2,458	3,528
1950	4,063	4,103
1951	8,316	8,816

During the period 1945-1953 research was continued on uses for olivine. F. J. Hansgirg did consideral work on the production of magnesium metal and magnesium compounds from North Carolina olivin Other studies were conducted on the uses of olivine in fertilizers and as roofing granule materials. Olivi remains one of North Carolina's major mineral resources which is relatively undeveloped.

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PHOSPHATE

Phosphate occurs in several areas of the Coastal Plain of North Carolina where it is associated with ocks of Eocene and Miocene ages. Relatively small amounts of black phosphatic pebbles are concentrated ear the base of the Castle Hayne (Eocene) formation. These beds are exposed in old quarries at Castle Iayne, New Hanover County, and near Rocky Point, Pender County. Fine-to-medium grains of brown hosphate occur in formations of Middle Miocene age and are fairly widespread in Beaufort County. Alhough the presence of phosphate in North Carolina has been known for many years, no commercial deposits ave been found.

Phosphate mining in the United States began in 1868 near Charleston, South Carolina, and that state was he sole producer until 1888, when production began in Florida. In 1892, large deposits were discovered in Vest Tennessee. During this period phosphate was being prospected over a wide area, and since it was known o occur in North Carolina, laws were passed in 1891 regulating mining on state-controlled lands. During he 1890's, attempts were made to mine phosphatic pebbles at Castle Hayne, New Hanover County, but there s no record of production.

During the period 1946-1953, interest in phosphate was revived when American Metals Company, Limited, egan investigating deposits in Beaufort County, especially in the areas near Washington and Pantego. here, brown phosphatic grains occur in Middle Miocene formations at about 50 feet below the surface. On uly 18, 1952, Arnold M. Davis, acting on behalf of Amco Exploration Company, was granted a lease by the tate of North Carolina to prospect for phosphate-bearing minerals underlying Pamlico River and its tribuaries in an area extending from about 6 miles upstream from Washington to approximately 30 miles downtream from Washington. Exploration was conducted between July 18, 1952, and May 11, 1953. During his period, approximately 50 holes were drilled and a considerable amount of other exploratory work was one, but no deposits of economic importance were found.

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QUARTZ

Quartz is an oxide of silicon (SiO_2), commercially referred to as silica, and is an important mineral resource vhen of sufficient purity. Most of the industrial quartz contains more than 98 percent silica and has a very ow iron-alumina content. Quartz is the most widespread of minerals, occurring as an important constituent n igneous, metamorphic, and sedimentary rocks. In quantity, it occurs chiefly as massive veins, sand, sandtone, quartzite, and as segregations in pegmatites.

Among the more important uses of quartz are in pottery, scouring soaps, glass, paints, wood fillers, tooth owders, sandpaper, as a flux, and in the manufacture of ferrosilicon. It is also used in the manufacture of hemical ware, as filters for acid towers, and in various types of lenses. Some varieties have value as gem nd ornamental stones.

There are large bodies of quartz in various sections of North Carolina. Some are of sufficient purity and ize to be valuable, others cannot meet requirements without beneficiation. In the central Piedmont, quartz eins are plentiful in Moore, Montgomery, and Randolph Counties, where they occur in rocks of the Volcaniclate series. There are also sizable bodies in Anson, Cherokee, and Jackson Counties. High-silica sands nd gravels are found in the eastern Piedmont and Coastal Plain regions, especially in Anson, Moore, Hoke, Iarnett, Bladen, and New Hanover Counties. Impure sandstones of Triassic age occur along the eastern iedmont but are of too low a quality to be of industrial use. Quartzite occurs in large quantities in Cheroee County and at one time was worked extensively to provide flux for the copper ores being processed at ucktown, Tennessee. Quartzites are also found in Burke, McDowell, Stokes, Surry, Cleveland, and Gason Counties. Tabular bodies of high-grade quartz often occur in the larger pegmatites, especially those in he Spruce Pine and Franklin-Sylva districts. During 1948, the Division of Mineral Resources of the North arolina Department of Conservation and Development and Regional Minerals Section of the Tennessee Valy Authority cooperated in a program to determine the quality and quantity of the major silica resources of he state. Analyses of typical materials are given in the accompanying tabulation.

ANALYSES OF TYPICAL HIGH-SILICA MATERIALS IN NORTH CAROLINA

Description	*SiO_2*	*Al_2O_3*	*Fe_2O_3*
Vein Quartz, northeastern Montgomery County	99.3	0.5	0.08
Quartzite, (Tusquitee) Swain County	93.5	5.6	0.09
Quartzite, (Erwin) Madison County	95.6	2.7	0.19
Quartzite (Nottley) Cherokee County	96.1	2.9	0.28
Sand, Sandhills region Moore County	98.7	1.1	0.11
Sand, Bladen County	98.21	0.73	0.09
Gravel, Anson County	98.8	0.92	0.13

Most of the production of high-silica material is from deposits of sand and gravel near Lilesville, Anson County, and as a byproduct of feldspar flotation near Spruce Pine, Mitchell County. Very pure massive quartz from some of the large pegmatites in the Spruce Pine district was used to make lenses during World War II. Quartz from the Chestnut Flats Mine was used in making the 200-inch lens for the world's largest telescope at California Institute of Technology.

The major producers of high-silica materials in North Carolina are Charlotte Chemical Laboratories, Inc., Charlotte, from deposits of sand and gravel near Lilesville, and International Minerals and Chemical Corporation as a byproduct of feldspar flotation at its Kona plant near Spruce Pine.

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SAND AND GRAVEL

Sand and gravel occur in many parts of North Carolina and are among the state's chief mineral assets. Deposits vary widely in occurrence and composition. Sand and gravel in the Mountain and Piedmont regions are confined largely to the flood plains and stream channels along the major drainage systems. The material comprising these deposits is poorly sorted and consists of various rock boulders and fragments, quartz, feldspar, mica, and lesser amounts of other minerals. In general, deposits are quite erratic in areal extent and large ones are uncommon. Deposits in the Coastal Plain follow old shore lines generally and are composed of relatively well sorted quartz sand and gravel, with minor amounts of clay and other materials. These deposits constitute the major reserves of sand and gravel in the state.

From 1946 through 1953, the value of sand and gravel accounted for 16 percent of the average annual value of minerals produced in the state and was second only to stone in both tonnage and value. The average annual production was 6,245,036 short tons, valued at $4,190,628, or about $0.67 per ton. This represents an increase of 122 percent in tonnage and 202 percent in value over the previous 10-year period. Production and value of sand and gravel marketed from 1946 through 1953 are presented in the accompanying table. The extensive secondary road building program carried out in North Carolina from 1950 through 1952 is reflected in the rapid rise in production for this period and the subsequent drop in 1953.

SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1946-1953

Year	*Short Tons*	*Value*	*Value/ton*
1946	4,213,795	$2,933,711	0.70
1947	4,171,553	2,956,800	0.71
1948	4,837,437	3,522,403	0.73
1949	5,092,929	3,553,180	0.70
1950	8,352,475	5,465,067	0.65
1951	7,656,370	4,435,702	0.58
1952	8,724,748	5,665,169	0.65
1953	6,910,982	4,992,991	0.72

Most of the sand marketed is concrete, mortar and paving sand; however, engine sand, molding sand, filter sand, and grinding and polishing sands are sold in lesser amounts. A high-silica sand produced in the Spruce Pine district as a byproduct of feldspar flotation is used in making glass. Gravel is used chiefly in building, paving, and as railroad ballast. Some high-silica gravel is sold for chemical purposes. Production figures of the types of sand and gravel sold in North Carolina during the period 1946-1953 are presented in the following tabulation.

KINDS OF SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1946-1953

YEAR	*BUILDING SAND*		*PAVING SAND*		*ENGINE SAND*		*OTHER SAND*	
	Short Tons	*Value*	*Short Tons*	*Value*	*Short Tons*	*Value*	*Short Tons*	*Value*
946	820,553	$ 365,333	1,734,515	$ 728,947	*	*	33,229	$ 52,996
947	901,131	395,994	1,687,798	563,833	*	*	93,489	126,505
948	877,894	533,347	2,199,239	834,072	25,702	$ 23,132	34,674	36,725
949	866,437	515,803	2,332,499	698,175	20,000	18,000	27,793	52,487
950	669,306	414,293	4,110,768	1,494,535	20,000	20,000	29,058	52,332
951	551,128	368,356	4,013,943	1,097,989	22,113	22,113	41,452	62,456
952	597,825	372,915	4,860,732	1,666,334	22,113	22,113	44,494	48,279
953	1,237,343	731,605	2,975,393	1,131,299	59,451	53,760	94,443	68,440

YEAR	*BUILDING GRAVEL*		*PAVING GRAVEL*		*R. R. Ballast Gravel*		*OTHER GRAVEL*	
	Short Tons	*Value*	*Short Tons*	*Value*	*Short Tons*	*Value*	*Short Tons*	*Value*
946	465,258	$ 615,545	1,109,971	$ 1,150,874	*	*	31,167	$ 30,016
947	446,316	631,726	993,058	1,188,153	*	*	49,761	48,589
948	441,404	670,466	1,228,612	1,396,446	*	*	29,912	28,225
949	369,640	562,726	1,457,054	1,689,498	*	*	19,506	16,491
950	363,857	477,512	3,127,733	2,980,004	26,102	18,914	5,651	7,477
951	400,790	504,395	2,475,633	2,243,604	122,702	99,807	28,507	36,982
952	62,150	88,300	3,077,277	3,414,003	*	*	60,157	53,279
953	687,513	1,039,282	1,577,395	1,690,006	*	*	279,444	233,569

* Production figures included with Other Sand and Gravel to prevent disclosure of confidential information.

Research carried out by the North Carolina Department of Conservation and Development and the North Carolina State College Minerals Research Laboratory indicates that some of the quartz sand now being used for structural purposes can be upgraded successfully to meet glass sand specifications. Beneficiation processes involved scrubbing and froth flotation, by which the iron content was reduced to 0.017 percent and the alumina to 0.4. Grain size falls within prescribed specifications.

The most important deposits in North Carolina are those in the Sandhills of Anson, Richmond, Moore, Hoke, Cumberland, and Harnett Counties. Large quantities of high-silica sand and gravel are produced near Lilesville, Anson County, and excellent grades of quartz sand are obtained from pits near Aberdeen and Eagle Springs in Moore County. During years past important amounts of sand and gravel were produced from near Lillington, Harnett County, and Thelma, Halifax County, but no production has been recorded for these areas recently. Deposits are being worked near Garysburg, Northampton County. Other areas in which important amounts of high-silica sands occur are near Wilmington, New Hanover County, Goldsboro, Wayne County, and various localities along the Outer Banks. Analyses of typical washed sand and gravel from the Coastal Plain are presented in the accompanying table.

ANALYSES OF SANDS AND GRAVELS FROM THE COASTAL PLAIN OF NORTH CAROLINA

Material	*Location*	*SiO_2*	*Al_2O_3*	*Fe_2O_3*
Sand	Aberdeen	98.5	1.25	0.25
Gravel	Lilesville	98.8	0.92	0.13
Sand	Wilmington	98.6	0.79	0.18
Sand*	Goldsboro	96.0	3.2	0.25

*Unwashed

Large amounts of sand and gravel are produced from flood-plain deposits near Fayetteville, Cumberland County; Old Fort, McDowell County, and Swannanoa, Buncombe County. Many small commercial operators and crews of the State Highway and Public Works Commission obtain sand from numerous small deposits scattered throughout the state.

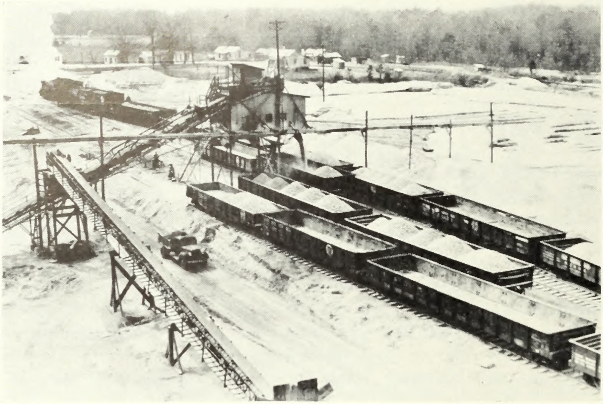

FIG. 19. LOADING SAND AND GRAVEL.

PRINCIPAL PRODUCERS OF SAND AND GRAVEL IN NORTH CAROLINA DURING 1953

Producer	*Address*	*Location of Operation*
Aberdeen Sand Company	Aberdeen	Moore
B. V. Hedrick Gravel and Sand Co.	Lilesville	Anson
Becker County Sand and Gravel Co.	Cheraw, S. C.	Cumberland, McDowell
Bell Sand Company	Asheville	Buncombe
Bryan Rock and Sand Company	Raleigh	Cumberland, Moore, Northampton, Wayne
Charlotte Chemical Laboratories	Charlotte	Anson
E. L. Robbins	Wilmington	New Hanover
Grove Stone and Sand Company	Swannanoa	Buncombe
Harrison Sand Pit	Eagle Springs	Moore
J. J. Colville Const. Co.	Bryson City	Jackson
Jobe Sand Company	Forest City	Rutherford, Cherokee
McCrary Const. Service	Asheville	Haywood
Monroe Sand Pit	Eagle Springs	Moore
Pleasants Sand and Supply Co.	Pinehurst	Moore
Reed and Abee	Asheville	Buncombe
Sake and Alexander	Waynesville	Haywood
N. C. State Highway and Public Works Commission	Raleigh	....

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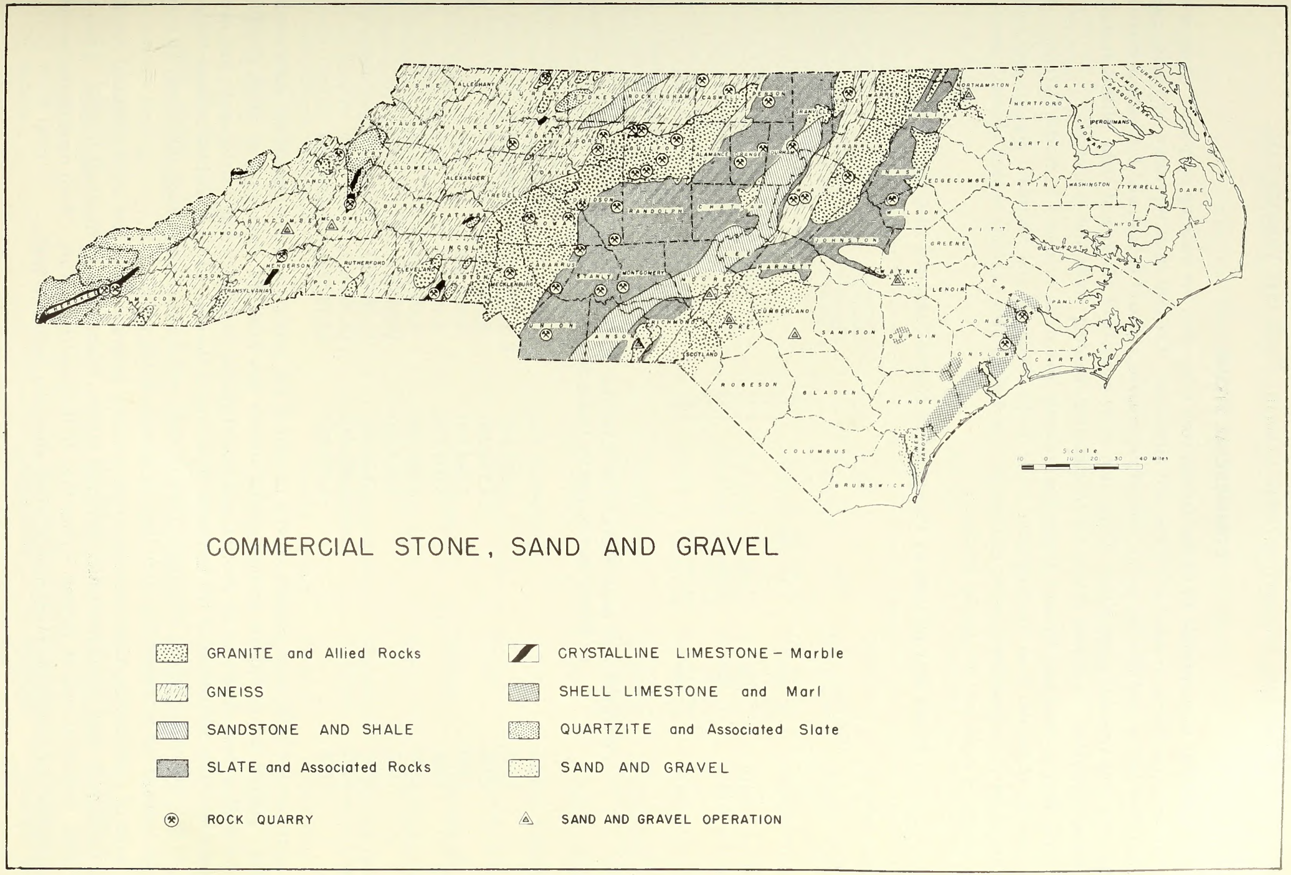

FIGURE 20. COMMERCIAL STONE, SAND AND GRAVEL.

COMMERCIAL STONE

Materials classed as stone include all of the various rock types used for building purposes. Stone is marketed in two principal forms, crushed or broken and dimension. Crushed stone represents by far the greate tonnage quarried and is used as road metal, concrete aggregate, railroad ballast, and for various other uses depending upon rock type and composition. Dimension stone consists of blocks and slabs which are cut int definite shapes and sizes. It is used chiefly for constructing masonry walls and memorials.

Stone ranks first in value and tonnage among the minerals and rocks produced in North Carolina. Mos of the production is derived from the crystalline rocks in the Piedmont and Mountain regions and include granite, limestone, slate, quartzite, gneiss, and marble. In 1951, North Carolina ranked eleventh among th states in volume of stone sold or used by producers.

STONE SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1945-1953

Year	*Short Tons*	*Value*	*Average Value Per Ton*	*Percent of National Production (Volume)*	*Rank in Nation (Volume)*	*Percent of State's Total Mineral, Production (Value)*
1945	2,297,670	$ 2,965,458	$ 1.29	1.5	20	20.5
1946	4,505,880	6,835,448	1.52	2.5	14	45.7
1947	5,018,060	7,561,167	1.51	2.4	13	46.2
1948	5,237,050	7,713,859	1.47	2.3	15	42.3
1949	6,225,290	10,077,976	1.62	2.8	14	51.0
1950	7,711,581	11,894,745	1.54	3.1	11	45.2
1951	8,612,976	13,292,690	1.54	3.0	13	44.8
1952	9,647,513	14,694,698	1.52	3.2	11	42.3
1953	9,317,390	14,424,323	1.55	*	*	37.5

CONCRETE AND ROAD METAL AND RAILROAD BALLAST SOLD OR USED BY PRODUCERS IN NORTH CAROLINA, 1945-1953

Year	*Short Tons*	*Value*	*Average Value*
1945	2,213,800	$ 2,435,287	$1.10
1946	4,105,280	5,630,158	1.37
1947	4,584,480	6,525,466	1.42
1948	5,003,470	6,437,330	1.29
1949	5,888,280	8,498,741	1.44
1950	7,634.220	10,277,717	1.35
1951	8,155,890	11,364,821	1.40
1952	9,608,415	13,350,621	1.39
1953	8,658,285	12,482,745	1.44

From 1946 through 1953, stone constituted 41.6 percent of the average annual value of the state's minera production. During this period the average annual volume was 7,034,466 short tons, of which granite accounted for 67.2 percent, limestone 26 percent, and miscellaneous stone, including marble, slate, and quatrzite, 6.8 percent. Over 99 percent of the marketed stone was in the crushed form, and the average value pe ton was $1.36. Dimension stone, principally granite, slate, and marble, represented only about 0.5 percen of the total tonnage but accounted for more than 11 percent of the value.

As a result of a 200-million-dollar secondary road building program authorized by the General Assembl of North Carolina in 1949, stone production advanced rapidly, reaching an all-time high in 1952. From 195 through 1953, production was 68 percent higher than in the previous 4 years. With most of the secondar road construction completed, the production of stone showed a decline in 1953.

PRINCIPAL PRODUCERS OF STONE IN NORTH CAROLINA, 1953

Company	*Quarry Location*	*County*	*Product*
Blue Ridge Stone Co.			
Gold Hill Quarry	Gold Hill	Cabarrus	Crushed Slate
Bryan Rock & Sand Co.			
Lassiter Quarry	Rolesville	Wake	Crushed Granite
Neverson Quarry	Sims	Wilson	Crushed Granite
Buchanan Stone Co.	Greensboro	Guilford	Crushed Granite
Cogdill Limestone Co.			
Fletcher Quarry	Fletcher	Henderson	Crushed Limestone
Columbia Marble Co.			
Hewitt Quarry	Marble	Cherokee	Dimension Marble
D. A. Sutton Stone Co.			
Sutton Quarry	Raleigh	Wake	Dimension Granite
Dooley Stone Co.			
Cycle Quarry	Cycle	Yadkin	Crushed Granite
Fletcher Limestone Co.			
Fletcher Quarry	Fletcher	Henderson	Crushed Limestone
Greystone Granite Quarries Co.			
Greystone Quarry	Greystone	Vance	Crushed Granite
Harris Granite Quarries Co.			
Balfour Quarry	Granite Quarry	Rowan	Dimension Granite
Carolina Quarry	Granite Quarry	Rowan	Dimension Granite
J. A. Logan Granite Co.			
Faith Quarry	Faith	Rowan	Dimension Granite
Jacobs Creek Flagstone Co.			
Woodard Quarries	Denton area	Davidson	Dimension Slate
Mount Gilead Quarry	Mount Gilead	Montgomery	Building Slate
Lambert Brothers, Inc.			
Pelham Quarry	Pelham	Caswell	Crushed Granite
Leon Simmons			
Simmons Quarry	Pollocksville	Jones	Shell Limestone
Nantahala Talc & Limestone Co.			
Hewitt Quarry	Hewitt	Swain	Crushed Limestone
Nello Teer Co.			
Teer Quarry	Durham	Durham	Crushed Slate
North Carolina Granite Corp.			
Mount Airy Quarries	Mount Airy	Surry	Dimension Granite
Piedmont Quarries Co.			
Winston-Salem Quarry	Winston-Salem	Forsyth	Crushed Granite
Guil Quarry	Stokesdale	Guilford	Crushed Granite
Salisbury Granite Industries			
Collins-Durax Quarries	Granite Quarry	Rowan	Dimension Granite
Superior Stone Company			
Bakers Quarry	Monroe	Union	Crushed Slate
McLeansville Quarry	McLeansville	Guilford	Crushed Granite
Midland Quarry	Midland	Cabarrus	Crushed Slate
Thomasville Quarry	Thomasville	Davidson	Crushed Slate
Woodleaf Quarry	Woodleaf	Rowan	Crushed Granite
Kings Mountain Quarry	Kings Mountain	Cleveland	Crushed Limestone
Belgrade Quarry	Belgrade	Onslow	Crushed Limestone
Wagoner Flagstone Co.			
Wagoner Quarries	Denton area	Davidson	Dimension Slate
Mount Gilead Quarry	Mount Gilead	Montgomery	Dimension Slate
Whitlow Brothers			
High Point Quarry	High Point	Guilford	Crushed Granite
CCC Quarry	Jamestown	Guilford	Crushed Granite

GRANITE

Granite and related crystalline rocks constitue the principal commercial stone deposits in North Carolina and are the basis of the major mineral industry in the state. During the past several years, North Carolina has ranked first in value of crushed granite and seventh in value of dimension stone.

Granite Sold or Used by Producers in North Carolina, 1946-1953

Year	*Dimension Stone* Short Tons	*Dimension Stone* Value	*Crushed Stone* Short Tons	*Crushed Stone* Value
1946	29,130	$ 646,142	2,911,870	$ 3,925,165
1947	17,550	622,797	3,281,370	4,559,574
1948	95,100	922,086	3,371,540	4,326,695
1949	20,790	1,000,184	4,322,590	6,540,107
1950	23,880	1,163,098	4,986,320	7,295,526
1951	23,458	1,309,981	6,000,932	8,603,558
1952	24,190	1,317,249	6,213,443	8,949,769
1953	41,392	1,403,666	7,423,787	10,344,668

Granitic rocks are widespread, lying at shallow depths or cropping out over approximately one-fifth of the total area of the state. Quarries for the production of crushed stone have been developed successfully at many localities, however more than 95 percent of current production comes from the central Piedmont region. Most of the dimension granite is quarried and finished near Mount Airy in Surry County and Salisbury in Rowan County.

Coastal Plain: Workable granites are exposed along the western border of the Coastal Plain, especially in Anson, Richmond, Wilson, Nash, and Edgecombe Counties. These granites have been worked intermittently for a number of years. During the period covered by this report the Neverson Quarry near Sims, Wilson County, was the major producer of crushed stone.

Northeastern Piedmont: Within the northeastern part of the Piedmont region, comprising Wake, Franklin, Warren, Vance, and Granville Counties, extensive deposits of granite occur. Most of them are unsuitable for monumental stone but can be used as crushed stone and in some cases as building stone. Important crushed stone quarries include the Greystone Quarry near Henderson, Vance County, and the Lassiter Quarry near Rolesville, Wake County. Building stone is produced from the Sutton Quarry, just north of Raleigh, Wake County. The northeastern Piedmont region ranks second in volume of commercial stone produced in the state.

Central Piedmont: The most important granite-producing area is the central Piedmont region, where a nearly continuous body of granitoid rocks extends northeastwardly across the state. It underlies parts of Gaston, Mecklenburg, Lincoln, Cabarrus, Iredell, Rowan, Davie, Davidson, Forsyth, Guilford, Alamance, Caswell, and Person Counties. Many crushed stone quarries are distributed throughout the region, the major producing quarries being the Woodleaf, Rowan County; McLeansville, Jamestown, Guil, High Point, and Buchanan, in Guilford County; Winston-Salem, Forsyth County; and the Pelham in Caswell County.

An excellent gray-to-pink granite occurs south and east of Salisbury in Rowan County and has been developed extensively as monumental stone. During the period 1946-1953, there were 2 finishing plants and 5 active quarries in this area. Important producers included the Harris Granite Quarries Company, Salisbury Granite Industries, Incorporated, and The J. A. Logan Granite Company. Trade names under which the Salisbury granite is marketed include Balfour Pink, Salisbury Pink Granite, Coral Pink, and Arabian Pink.

Western Piedmont: The western Piedmont division consists of a large area adjacent to and east of the Blue Ridge Mountains. Sizable deposits of granite occur in Stokes, Yadkin, Cleveland, Gaston, Polk, and Rutherford Counties and lesser amounts in Wilkes, Catawba, Caldwell, and Alexander Counties. Many small quarries have been developed for crushed stone but the most important development is near Mount Airy, Surry County, where a high-grade light gray dimension stone has been quarried since about 1890. Mount Airy granite is a famous building and monumental stone and is produced by the North Carolina Granite Corporation.

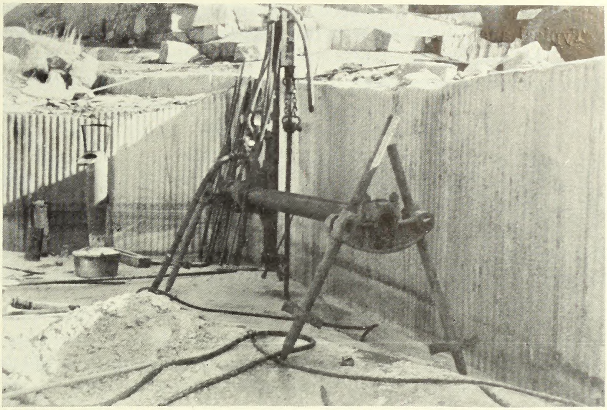

Fig. 21. Channeling Machine, Dimension Granite Quarry, Rowan County.

Blue Ridge: The Blue Ridge Mountains area includes several of the mountain counties. Massive granites re relatively rare, but granite gneisses are common in restricted areas. Among the more important occurrences are those in Swain, Henderson, Transylvania, Clay, and Macon Counties. Other deposits are in Jackson, Madison, Watauga, and Ashe Counties. There has been very little production from these counties within ecent years.

During 1952 and 1953, R. J. Councill, geologist with the Division of Mineral Resources of the North Caroina Department of Conservation and Development, investigated the commercial granite resources of the tate. Results of this work are published as Bulletin 67 of the Department of Conservation and Developnent.

LIMESTONE

Commercial deposits of limestone and marble are not common in North Carolina. Crystalline limestone ccurs as narrow, lenslike deposits within certain of the schistose formations of the Mountain and Piedmont reas, and shell limestone and marls are found in parts of the Coastal Plain. All of the major deposits have een worked commercially, most of the stone being marketed in the crushed form. Dimension stone and gricultural limestone are produced in lesser amounts. During the period covered by this report limestone ccounted for 26 percent of the stone quarried in the state and represented 23 percent of the value.

Production of Crushed Limestone in North Carolina, 1945-1953

Year	*Short Tons*	*Value*
1945	400,540	$ 465,525
1946	1,162,180	1,497,031
1947	1,265,010	1,731,630
1948	1,352,180	1,862,397
1949	1,546,920	2,103,055
1950	2,091,930	2,755,536
1951	2,182,010	2,946,554
1952	2,654,282	3,583,909
1953	2,357,498	3,273,216

Limestones of the Mountain and Piedmont Regions: Crystalline limestone, generally quite dolomitic in haracter, is found at several places in the Mountain and Piedmont areas, but deposits of economic value are carce. The larger known occurrences are those in Cherokee, Swain, Madison, McDowell, Henderson, and

Cleveland Counties. Smaller deposits are in Mitchell, Buncombe, Transylvania, Gaston, Catawba, Yadkin, and Stokes Counties. Typical analyses of some of the limestones are given in the accompanying table.

ANALYSES OF DOLOMITIC LIMESTONES OF NORTH CAROLINA

Location	SiO_2	R_2O_3	Fe_2O_3	*CaO*	*MgO*	*Ignition Loss*
Quarry near Marble, Cherokee County	2.1	0.8	0.27	51.9	2.5	42.5
Quarry, Hot Springs, Madison County	3.8	1.5		29.3	20.2	44.5
Average of 6 analyses from quarries at Fletcher, Henderson County	2.0	1.10	0.33	31.0	19.0	45.7
Near Woodlawn, McDowell County	3.9		0.36	28.8	19.0	45.1
Quarry near Kings Mountain, Cleveland County	22.4	9.3	0.33	31.2	5.3	28.7

The most extensive crystalline limestone is the Murphy marble, which extends continuously for about 30 miles northeastward across Cherokee County and occurs in smaller amounts near Hewitts in Swain County. In Cherokee County the formation has a maximum thickness of approximately 500 feet and contains beds of white, blue, red, pink, and dark-banded dolomitic marble which are excellent for monumental, decorative, and building stone. Many openings have been made in the marble, but the only active dimension-stone quarry is that of the Columbia Marble Company at Marble, Cherokee County. The Nantahala Limestone and Talc Company operates a quarry and crushing plant at Hewitts, Swain County.

At Hot Springs, Madison County, limestone of the Shady formation forms steep banks along the French Broad River. During the early part of the century, this limestone was quarried rather extensively, but production has been negligible during recent years.

In McDowell County, principally between Linville Falls and Woodlawn, a large fault block of Shady limestone is exposed along the North Fork of the Catawba River. This stone has been used both for making lime and as crushed stone. During the period covered in this report production was limited to crushed stone produced by the North Carolina Highway and Public Works Commission from the quarry 0.25 of a mile south of Woodlawn and approximately 8.5 miles north of Marion.

Small lenses of limestone, associated with the Brevard schist, occur in Buncombe, Henderson, and Transylvania Counties. The largest exposures are near Fletcher in Henderson County, where the Fletcher Limestone Company and the Cogdill Limestone Company are quarrying and crushing the rock for concrete aggregate, road metal, and agricultural purposes.

The largest limestone quarry in the state is located just south of Kings Mountain, Cleveland County, and is operated by the Superior Stone Company for crushed stone. The rock is a medium- to fine-grained, dark bluish-gray dolomitic limestone and is quite siliceous. It occurs as a series of lenslike bodies within a schistose formation which extends from near Gaffney, South Carolina, to Bessemer City, North Carolina. The quarry, located on one of the larger lenses, is a major source of crushed stone in the south-central part of North Carolina.

Small amounts of crushed limestone have been produced from deposits near Maiden, Catawba County, and Lime Rock in northern Yadkin County. No activity was reported from these areas from 1946 through 1953.

Limestones of the Coastal Plain: Shell limestones and marls occur in varying amounts along the central and eastern portions of the Coastal Plain. Most of the larger commercial deposits are associated with the Castle Hayne and Trent formations, which crop out from near Wilmington northeastward to beyond the Neuse River. The principal production has come from near Castel Hayne, New Hanover County; Warsaw, Duplin County; Belgrade, Onslow County; Pollocksville, Jones County; and New Bern, Craven County.

Analyses vary from one locality to another but are often quite consistent within a given area. On the McRae property in southern Pender County, the marl averages about 89.5 percent $CaCO_3$, 5.5 percent SiO_2, 2.3 percent of Fe_2O_3, Al_2O_3, and P_2O_5, and 1.23 percent $CaSO_4$. Samples from near Mapel Hill in northeastern Pender County averaged about 90.9 percent CaO_3, 1.4 percent $MgCO_3$, 3.2 percent SiO_2, 0.8 percent Fe_2O_3, and 1.4 percent Al_2O_3. At Belgrade in Onslow County, chip samples from an old quarry analyzed 83.25 percent $CaCO_3$, 2.96 percent $MgCO_3$, and 12.21 percent SiO_2.

Between 1945 and 1953 most of the production in the Coastal Plain region was from the Superior Stone ompany's quarry at Belgrade and the Simmons pit near Pollocksville. Small amounts of marl were prouced locally at many places. In 1946, a general survey of the marls and limestones was made by E. Willard erry for the North Carolina Department of Conservation and Development, and results are published as ulletin 54.

SLATE

Since 1946, rocks of the Volcanic-Slate series have been used in increasing quantities as sources of stone. ost widely used are the greenish-gray to blue bedded slates, and large crushed stone operations are located ear Monroe and Bakers, Union County; Midland and Gold Hill, Cabarrus County; Thomasville, Davidson ounty; and Braggtown, Durham County. Flagging, building stone, and cut-stone specialties are produced rom thin-bedded slates in Davidson and Montgomery Counties. In Orange County, building stone is obtain-d from the Duke University Quarries near Hillsboro. Slates account for most of the production listed under iscellaneous stone.

MISCELLANEOUS CRUSHED OR BROKEN STONE PRODUCED IN NORTH CAROLINA, 1945-1953

Year	*Short Tons*	*Value*
1945	108,160	$121,004
1946	402,000	681,980
1947	386,270	529,849
1948	417,670	539,672
1949	334,680	398,704
1950	511,891	519,783
1951	330,928	336,667
1952	642,910	698,087
1953	480,084	581,636

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TALC, SOAPSTONE, AND PYROPHYLLITE

TALC AND SOAPSTONE

Industrial talc and soapstone include materials of different chemical and mineral compositions, most of hich are silicates containing considerable amounts of magnesia. The hydrous magnesium silicate talc, $_2Mg_3(SiO_3)_4$, is the most important. Theoretically, talc contains 31.7 percent MgO, 63.5 percent SiO_2, and 8 percent H_2O. It is characterized by its softness, greasy feel, and heat-resistant properties. Steatite is compact massive type of very pure talc which contains less than 1.5 percent CaO, 1.5 percent FeO + Fe_2O_3, nd 4 percent Al_2O_3. The term soapstone or merely talc usually refers to more impure varieties. Economic eposits of talc and soapstone usually occur in metamorphosed dolomitic limestones and altered ultrabasic cks.

Talc has a wide variety of uses, and few, if any, minerals surpass it in industrial usefulness. In paint, it ts as an extender and pigment, and most of the high-grade talc is ground and marketed for this purpose. he roofing industry is the second largest consumer of ground talc, the lower grades and off-color talc being ed as a filler and for coating materials. Large quantities of talc are used in the ceramic industry in the reparation of electrical porcelains, insulation, glazed wall tile, and semivitreous tableware. It is an important ingredient in sagger bodies and kiln furniture. Among its other industrial applications are in the m ufacture of insecticides, textiles, cosmetics, foundry facings, lubricants, crayons, and for making castin Block and molded or bonded talcs are used widely for numerous electrical, chemical and refractory artic

There are two important ways in which talc occurs in North Carolina: (1) as irregular bodies form by the alteration of ultrabasic iegneous rocks and (2) as lens-shaped replacement bodies in dolomitic lin stones. Most of the talcose materials derived from the basic rock types are low grade; however, sm amounts of a quite pure apple-green talc is present in some of the peridotite formations. These low-gra talcs and soapstones occur principally in the Mountain and western Piedmont regions of the state especial in Jackson, Buncombe, McDowell, Madison, Ashe, Allegheny, and Yancey Counties. Sizable deposits oc in northern Wake and southern Granville Counties. Various attempts have been made to use them but s cess has been limited because of the grade of the product.

Talc deposits in the crystalline limestones of Cherokee and Swain Counties constitute the most import reserves of minable talc in the state. The talc occurs as lenslike bodies from a few inches in length a width to those more than 200 feet long and 50 feet wide. These deposits have been mined intermitte since 1859, and have accounted for most of the production in North Carolina. The industry is centered n Murphy, Cherokee County.

Talc is mined by open-cut and underground methods and delivered to plants where it is either sawed i crayons or ground to specifications. The quality of the talc in the Murphy area is high, competing favora with the standard and premium grades from California, Italy, and France. The average price per ton ground talc in 1953 was in excess of $40.00 and for sawed talc approximately $600.00.

A detailed geological survey of the talc deposits in the Murphy Marble Belt was made between 1945 a 1947 by the Tennessee Valley Authority in cooperation with the North Carolina Department of Conservat and Development, and the results were published as Bulletin 56 of the Department of Conservation and velopment. During and following this investigation, there was considerable exploration in the distr At the request of the talc industry, the North Carolina State College Minerals Research Laboratory m beneficiation tests on stained talc, which resulted in the successful marketing of this waste material. Res of the project are published in Report of Investigation 2 of the Minerals Research Laboratory. Between 1 and 1953, the production of talc in North Carolina more than doubled.

Principal Producers of Talc in North Carolina during 1953

Producer	*Address*	*County*
Hitchock Corporation	Asheville	Cherokee
Minerals and Metals Corporation	Murphy	Cherokee
Mauney Mining Company	Murphy	Cherokee

PYROPHYLLITE

Pyrophyllite is a hydrous aluminum silicate having the general formula $H_2Al_2Si_4O_{12}$ and theoretically c taining 28.3 percent alumina, 66.7 percent silica, and 5 percent water. In physical and optical properties, i quite similar to talc; in chemical composition, it differs principally by its containing alumina rather th magnesia. Pyrophyllite occurs in three principal forms: (1) as radiating crystals, (2) as foliate or mi ceous masses, and (3) as massive homogeneous material. It is a replacement mineral and forms irregu bodies in rocks of volcanic origin where it is often associated with andalusite, diaspore, topaz, and other hi alumina minerals.

Like many other nonmetallic minerals, pyrophyllite has a wide range of industrial uses. Among the m important are in ceramics, refractories, insecticides, cosmetics, paint, plastics, insulation, bleaching p der, textiles, rubber, soap, and wallboard. Most pyrophyllite is pulverized prior to being marketed, and i value is often based on particle size, chemical and mineral content, and color. High-grade refractory is sold in the crude or crushed form.

Commercially valuable sources of pyrophyllite are limited to North Carolina and California. The most portant are those deposits lying along the eastern edge of the Piedmont Plateau of North Carolina, pri lly in Moore, Montgomery, Randolph, Chatham, Alamance, and Granville Counties. Approximately 90 rcent of the total domestic supply comes from these deposits.

Individual bodies are roughly lens-shaped and range in size from those measured in inches to deposits up 500 feet wide and 1500 feet long. They occur along fracture zones in volcanic rocks and are often asso- ated with considerable amounts of fine quartz and sericite and lesser amounts of andalusite, diaspore, ky- nite, topaz, pyrite, and chloritoid. Most of the commercial ores consist of pyrophyllite with varying pro- rtions of other alumina minerals, fine quartz, and sericite. Mining is by open-cut and underground meth- ds, and the crude ore is trucked to processing plants, usually within a short distance of the mine. Most of e production is from a few large deposits, and known available reserves are somewhat limited.

The period 1946-1953 was one of considerable activity for the pyrophyllite industry of the state, and con- derable prospecting, exploratory drilling, and research on ore beneficiation were carried out. The discovery the presence of high-alumina minerals in some of the lower grade ores resulted in a reappraisal of reserves d several research projects designed to establish economic methods for the treatment of the lower grade es. The North Carolina Department of Conservation and Development's Division of Mineral Resources rried out geologic investigations of the region and prepared maps of some of the more outstanding de- osits. The Carolina Pyrophyllite Company, formerly a subsidiary of United Feldspar and Minerals Corpo- tion, was purchased by American Encaustic Tiles Corporation. Offices and a testing laboratory were tablished in Greensboro. The Standard Mineral Company reopened the old Womble Mine near Glendon, d North State Pyrophyllite began production from its pyrophyllite-andalusite deposit at Hillsboro. Caro- na Pyrophyllite Company erected a differential grinding unit at its Staley plant and conducted detailed ploration program at the Mays property on Bowlings Mountain, Granville County, and other properties Randolph, Moore, and Montgomery Counties. A modern grinding plant was erected at Glendon to replace older plant which was burned.

Most of the pyrophyllite mined in North Carolina is ground and shipped out of the state for industrial plication. Pyrophyllite refractories are, however, manufactured at Pomona, Guilford County, by the rth State Pyrophyllite Company.

PRODUCERS OF PYROPHYLLITE IN NORTH CAROLINA, 1953

Company	*Address*	*Mine Location by County*
Carolina Pyrophyllite Co.	Greensboro	Randolph, Moore Granville
North State Pyrophyllite	Pomona	Alamance, Orange
Standard Mineral Company	Robbins	Moore

PRODUCTION

The combined average annual production of talc and pyrophyllite in North Carolina from 1946 through 53 was 105,100 short tons, valued at $1,560,260, or $14.46 per ton. This was more than twice the tonnage d nearly 3.5 times the value of the production of the preceding ten years. Although actual production ures cannot be revealed, pyrophyllite accounted for more than 90 percent of the tonnage mined.

PRODUCTION OF TALC AND PYROPHYLLITE IN NORTH CAROLINA FROM 1946 THROUGH 1953

Year	*Short Tons*	*Value*
1946	87,718	$ 976,524
1947	97,484	1,186,463
1948	104,452	1,455,691
1949	86,208	1,344,767
1950	116,895	1,855,163
1951	113,950	1,982,927
1952	115,481	1,771,518
1953	118,614	1,909,027

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VERMICULITE

Vermiculite is the name applied to a group of micaceous minerals which exfoliate when heated rapi Pure vermiculite is a hydrated aluminum magnesium iron silicate and has the formula $(OH)_2(Mg,F$ $(Si,Al,Fe)_4O_{10}\cdot 4H_2O$. It forms generally by the alteration of basic rocks. The mineral is green, amb brown or black, has a greasy feel, and a pronounced micaceous cleavage. When subjected to high temp tures, the water in vermiculite is converted into steam and driven off rapidly, causing the mineral to exp in bulk volume from 8 to 12 times and to change from about 100 pounds per cubic foot in the raw stat from 4.5 to 20 pounds per cubic foot after exfoliation. Industrial plants effect exfoliation at about 2000

After expansion vermiculite has many industrial uses, largely depending upon its thermal insulating q ities, light weight, fireproofness, or its granular form. It is available in the following general size rang minus ½-inch plus 3-mesh, minus 3-mesh plus 14-mesh, minus 8-mesh plus 20-mesh, minus 8-mesh plus mesh, minus 10-mesh plus 65-mesh, minus 20-mesh plus 100 mesh.

The larger sizes are used as loose-fill insulation in various types of structures, refrigeration, cold stor high-temperature refractory surfaces, and various types of high and low-temperature industrial equipm Medium sizes are used as aggregate for plaster and insulating concrete. Expanded vermiculite is also u in conditioning soils, insulating plastics, pipe lagging, roofing insulation, as a lubricant and filler, in insu ing refractory bricks and blocks, and in many other products.

Montana ranks first and South Carolina second in the production of domestic vermiculite. In North Ca lina, vermiculite was first recognized at Corundum Hill, Macon County, in 1873. The first continuous prod tion in the Eastern United States was in 1933 from deposits in Macon and Buncombe Counties, North Carol and since that time the state has been a small but steady producer of high-grade vermiculite.

Deposits of commercial importance in North Carolina are associated with a series of basic magne rocks (dunite), which extends from Clay County, northeastwardly into Avery County. Other occurre are in the Piedmont region, especially in parts of Forsyth and Davie Counties, but they are generally small to be of value. The larger deposits consist of peripheral zones along contacts or interior veins wi the basic rock formations, occurrences which are not favorable for large-scale mining. Most of the mi in North Carolina has been in the Ellijay area of Macon County, the Bee Tree area near Swannanoa in B combe County, and the Toecane and Green Mountain areas of Yancey County. Based on a survey mad 1944 by the North Carolina Department of Conservation and Development and the Tennessee Valley thority, reserves of vermiculite in North Carolina are estimated at from 202,000 tons to 440,000 tons.

PRINCIPAL PRODUCERS OF VERMICULITE IN NORTH CAROLINA, 1950

Company	*Address*	*Location of Operation, County*
Vermiculite Suppliers, Inc.	Sylva	Jackson
American Vermiculite Co.	Spruce Pine	Yancey
Variegate Vermiculite Co.	Green Mountain	Yancey

During the period 1945-1953, the average annual production in North Carolina was 1,153 short tons, va at $14,367.00. Maximum production was in 1950, when over 3000 tons were mined. In 1953, crude verm lite was quoted at from $12 to $14 per ton. The vermiculite industry was active both in the Franklin-S ad Spruce Pine mining districts, exfoliation plants being located near Franklin, Sylva, and Spruce Pine. rior to 1949, most of the production was from Macon County, but in 1949 mining also was recorded from ackson and Yancey Counties. Following 1950, production dropped rapidly in the southwestern counties, ad by 1953 only one company in the state, the Variegate Vermiculite Company of Green Mountain, report- d production. In some instances shutdowns are temporary and mines are expected to be back in operation 1955.

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RARE EARTH AND OTHER MINOR MINERALS

Within this classification are a group of relatively rare minerals, which, during the past few years, have come of major importance in nuclear development and for other specialized purposes. Some of these min- als occur in such small quantities in North Carolina as to be of scientific interest only, others have possi- lities of being produced in limited quantities. During the period 1946-1953, an intensive prospecting pro- am for these minerals has been conducted throughout North Carolina. Although no major deposits have en found, new occurrences of uranium and rare earth minerals have been discovered.

BERYL

Beryl is a silicate of beryllium having a general formula $Be_3Al_2\ (SiO_3)_6$, most commercial grades containing om 10 percent to 12 percent beryllium oxide. Beryllium is of considerable importance in nuclear studies, nce it slows down but does not absorb neutrons, has favorable heat-transfer characteristics, is very light weight, and has a high melting point. It is very useful as a structural material or moderator for high ficiency atomic pile construction. Beryllium-copper alloys are used in making springs and nonsparking ols. Important defense uses are in aircraft engines, springs for instruments, and in parts of tanks, ships, d guns.

Beryl occurs in small quantities associated with pegmatite formations in the Piedmont and Mountain re- ons of North Carolina. Small amounts are produced as a byproduct of mica and feldspar mining in the ruce Pine district of Avery, Mitchell, and Yancey Counties. It also has been found in Alexander, Burke, eveland, and Jackson Counties. In Cleveland, Gaston, and Lincoln Counties, beryl occurs as a minor con- tuent of the tin-spodumene pegmatites. Studies carried out during 1949 by the United States Geological rvey indicate that reserves in the Tin-Spodumene Belt amount to about 823,000 tons. However, the aver- e BeO content of most pegmatites is approximately 0.05 percent. Recovery of beryl in commercial amounts om this district must be as a byproduct operation of spodumene mining and concentration.

COLUMBITE-TANTALITE

These minerals are columbium and tantalum oxides of iron and manganese and vary widely in composition, re columbite containing 75 percent columbium oxide and pure tantalite containing about 80 percent tanta- n oxide. Minor quantities of uranium are usually present. Columbium is used in the manufacture of ainless steel and high-temperature-resistant alloys for use in jet engines, turbines, and similar types of uipment. Tantalum is used in vacuum tubes, as catalysts, in high-speed cutting tools, and surgery.

Columbiite and tantalite occur as pegmatite minerals and have been found at a number of localities in rth Carolina, but no large deposits have as yet been discovered. In the Spruce Pine district small ounts are produced annually as a byproduct of feldspar and mica mining, the more important occurrences ing at the Wiseman and Deake Mines in Mitchell County and the Ray Mine and near Mine Fork in Yancey unty. These minerals also have been found near Franklin, Macon County; White Plains, Alexander unty; Balsam Gap Mine, Buncombe County; Brindletown, Burke County; and Casar, Cleveland County. all amounts of columbite and tantalite occur in the tin-spodumene pegmatites of Cleveland, Gaston, and ncoln Counties. Some of these minerals were produced in 1952 as a byproduct of spodumene mining and ncentrations.

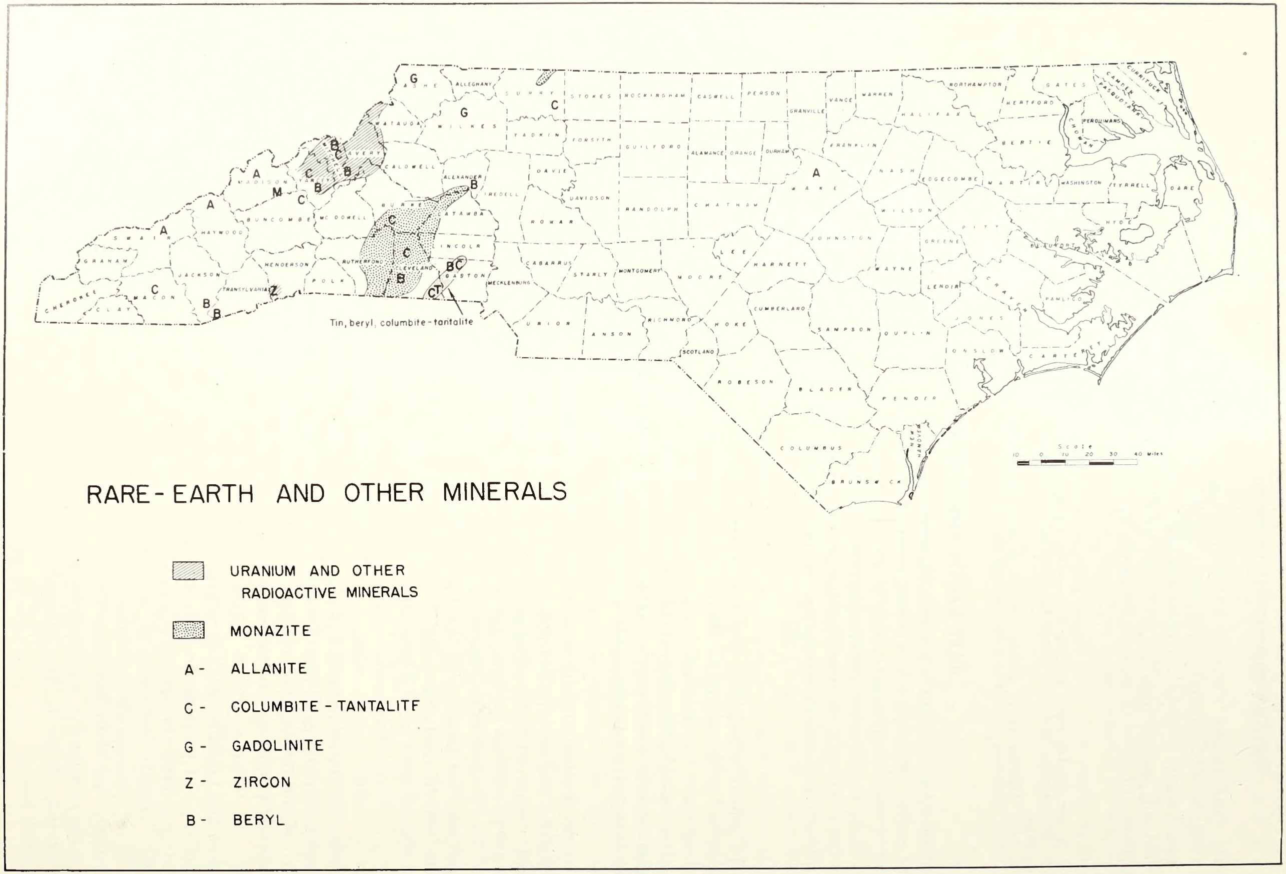

FIGURE 23. RARE EARTH AND OTHER MINERALS

ALLANITE-GADOLINITE

Allanite: Allanite is a hydrous silicate of calcium, iron, cerium, and other of the rare earths. It is usually slightly radioactive because of the presence of minor quantities of thorium. This black to dark brown mineral has a glassy to resinous luster and a specific gravity ranging from 2.7 to 4.2, depending upon the degree of alteration. In North Carolina, small amounts of allanite have been found in most of the pegmatite areas. It is most common in the zone between granites and gneissic rocks extending from near Bryson City, Swain County, to the western part of Ashe County. Interesting occurrences are in Swain, Madison, Watauga, and Ashe Counties. It is also present in the Spruce Pine district of Avery, Mitchell, and Yancey Counties, and in northeastern Wake County.

Gadolinite: Gadolinite is quite similar to allaniite in appearance but is a silicate of iron, beryllium, and yttrium rare earths. Often the rare earths are replaced in part by thorium. Uranium may be present in amounts up to 0.5 percent. The beryllium content ranges from 6 percent to 12 percent. Gadolinite is the primary source of gadolinium, a very rare member of the yttrium group. It occurs associated with allanite and other rare earth minerals. It has been reported in the pegmatites of Ashe and Wilkes Counties.

During the period 1946-1953, allanite-gadolinite occurrences were being thoroughly prospected in Ashe and Watauga Counties and adjacent areas in Tennessee.

MONAZITE

Monazite is essentially a phosphate of rare earths, principally cerium. It has a general formula $R\ Po_4$ where R represents varying amounts of lanthanum, cerium, praseodymium, neodymium, samarium, and lesser amounts of the terbium and yttrium earths. Monazite contains from 1 to 15 percent thorium oxide and from about 0.10 percent to 1 percent U_3O_8. Because of its high-thoria content and the presence of other earths, monazite is quite radioactive. The mineral has a resinous to vitreous luster and is honey yellow, greenish yellow, and various shades of brown in color. It is a widely disseminated accessory mineral in many metamorphic and granitic igneous rocks and usually occurs as rather small grains. Large crystals have been found in some pegmatites.

The rare earths in monazite have rather limited but highly specialized uses. Ceria and other rare earths are used in making glass; cerium oxides and fluoride in high powered lamp carbons; and cerium acetate as a water- and mildew-proofing compound. Thorium is used in the manufacture of radio tubes, tungsten lamp filaments, high-temperature refractories, as a catalyst, and as an alloy. Lanthanum salts are utilized in beauty preparations, and erbium salts, as astringents. Within recent years monazite has become of increasing interest because of its great potential importance as a substitute for uranium in the future production of nuclear power. U^{233} can be produced from Th^{232} by means of a breeder reaction.

The principal domestic sources of commercially mineable monazite are limited to areas in Idaho and the southeastern states. In the Piedmont region of the southeastern states, there are two belts in which monazite is most highly concentrated. The major one extends from near Fredericksburg, Virginia, southwestward across North Carolina, South Carolina, and Georgia to southeastern Alabama. A smaller belt branches from the main belt west of Richmond and extends southward into southern Wake County, North Carolina.

In North Carolina the principal occurrences of monazite are in Rutherford, Cleveland, and Burke Counties. The more important known deposits are near Ellenboro, Rutherford County; Shelby, Casar, and Mooresboro, Cleveland County; in the Brindletown and Camp Creek areas of Burke County; and along Silver, South Muddy and North Muddy Creeks and Henry and Jacobs Fork of the Catawba River in Burke County. It also occurs near Mars Hill, Madison County, and Mount Airy, Surry County.

The monazite in North Carolina occurs sparingly as small grains in granites, gneisses, and schists. Concentrations of possible economic importance are restricted to placer deposits resulting from the weathering of these rocks and the deposition of the minerals and rock fragments adjacent to stream channels. Investigations of 20 of the larger deposits show that the monazite content averages less than one percent. Other minerals present include magnetite, ilmenite, garnet, zircon, and other heavy minerals. Thirty-six samples of monazite from North Carolina, collected by the United States Geological Survey, averaged 5.73 percent thoria and 0.39 percent U_3O_8. Analyses of three samples collected by the Tennessee Valley Authority a as follows:

Sample	ThO_2	SiO_2	P_2O_5	CeO_2	La_2O_3, *etc.*
A	5.15	2.35	28.0	28.0	33.0
B	6.80	3.31	27.2	28.4	31.4
C	6.50	3.80	28.3	27.7	31.7

Monazite was first discovered in North Carolina in 1879, and placer deposits began to be developed ab 1886. The first shipment was in 1887, and a maximum production of 787 short tons of concentrates was tained in 1895. With cheap foreign ores becoming readily available, domestic production declined rapi and by 1911 had ceased in North Carolina. From 1915 to 1918, mining was resumed temporarily; si that time, it has been sporadic and production negligible. During the years of active mining the avera annual production was approximately 255 short tons.

During the period 1945-1953, there was considerable interest in monazite as a raw material in the rapi expanding field of nuclear science. Many of the old properties were leased, and one attempt at mining a concentrating was made in northeastern Rutherford County. Most active in the area were Blue Ridge M ing Company of Forest City, North Carolina, Rare Earths, Incorporated, of Patterson, New Jersey, and S. Royster Monazite Company of Shelby, North Carolina. There is no record of production during the peri The United States Geological Survey carried out detailed geologic mapping in the Shelby area and outli some of the larger deposits. Studies of monazites throughout the Southeastern States were carried out J. B. Mertie, Jr., of the U. S. Geological Survey, and results are published as Circular 237 of the survey. D ing 1951 and 1952 the United States Bureau of Mines carried out a detailed drilling and sampling progr in the Shelby and surrounding districts. A small pilot plant was established in Shelby to concentrate mo zite from the field samples.

ZIRCON

Zircon ($ZrSiO_4$) is a silicate of zirconium, having a theoretical zirconium content of 67.2 percent b varying from 61 percent to 66.82 percent as found in nature. It is used in ceramics, chiefly as an opacifier i porcelain enamels and pottery glazes, as a constituent of refractories, electrical and chemical porcelains, gri ing balls, and resistant glasses. Zirconia is advantageous in electrical heating units since it is both a c ductor of heat and an insulator of electricity. One of the largest uses of zircon is as a foundry sand. Z conium metal, the most explosive metal powder, is used in radio tubes, blasting caps, and flares. Metallurgi zirconium is a deoxidizer and scavenger. It is also an alloy metal. Within the past few years it has beco of importance in atomic energy development.

Zircon is rather common in crystalline rocks and is often classed as a rock-forming mineral. It is fou also as detrital grains in sedimentary rocks. The principal occurrences of zircon in North Carolina are ne Tuxedo (Zirconia) Henderson County; Mars Hill, Madison County; New Sterling, Iredell County; and ne Reddis River, Wilkes County. It also occurs in the granites and pegmatites in the monazite regions Burke, Cleveland, and Rutherford Counties. Of these, the occurrence near Tuexdo in southern Henders County is the most important as a potential source of zircon.

The zircons of Henderson County occur in a well kaolinized pegmatite, approximately 100 feet wide, wh they are associated with xanthinite, auerlite, and other rare earth minerals. The deposit was discovered i 1869, and the first shipment of concentrates was made in 1888. Production was from two mines on the sa ore body, the Freeman and Jones. Between 1902 and 1911, 20,512 pounds of zircon were shipped from t locality, the last production being 3,208 pounds in 1911.

URANIUM MINERALS

Several of the uranium-bearing minerals have been found in North Carolina, among the better known a autunite, clarkeite, cyrtolite, euxenite, gummite, samarskite, torbernite, uraninite, and uranophane. Sm amounts of uranium occur in monazite, gadolinite, and possibly allanite. The uranium-bearing minerals a found principally as minor constituents in pegmatites in North Carolina. They appear to be most abundant in the Spruce Pine district and adjacent areas, where small amounts have been recovered as byproducts of feldspar and mica mining. Some of the better known localities are the Flat Rock, Wiseman, Deake, and Thompson Mines in Mitchell County and the Ray Mine and Green Mountain area of Yancey County.

Torbernite and other radioactive minerals have been found in schists and underlying granitic rocks, which cover large areas in the Pisgah National Forest, especially in northern Burke, Mitchell, Avery, and adjacent counties. However, the percentage of these minerals is reported to be quite small. Some of the iron ores of Ashe County are reported to be slightly radioactive.

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MINERAL FUELS

COAL

Coal has been found at several localities in North Carolina and has been mined intermittently for over 175 years. The more outstanding occurrences are along Deep River in parts of Chatham, Lee, and Moore Counties and in the Dan River basin of Stokes and Rockingham Counties. Minor quantities have been reported from localities in eastern Chatham, southern Moore, and Richmond Counties. All of the known occurrences are limited to rocks of Triassic age.

Deep River Coal Field: The only area in North Carolina in which commercially important beds of coal are known to occur is the Deep River Coal Field, about 10 miles northwest of Sanford. It is located in parts of Chatham, Lee, and Moore Counties and occupies a zone approximately 35 miles long and from 5 to 10 miles wide along Deep River. Most of the mining and development work has been in the outcrop zone west of the river. Because of the highly faulted condition of this zone and a lack of geologic information concerning the structure of the area as a whole, the Deep River Coal Field has not developed into an important producer.

Recent studies by geologists of the United States Geological Survey, including detailed mapping supplemented by deep-drilling tests by the United States Bureau of Mines and private interests, show that "almost all the thick mineable coal in the Deep River coal field is in a canoe-shaped down-faulted block bounded on the northwest by the Gulf fault and on the southeast by the Deep River fault. The coal on the southeast side of the Gulf fault has been dropped as much as 750 feet below the coal on the northwest side of the fault, and the coal on the northwest side of the Deep River fault has been dropped as much as 2000 feet below the coal on the southeast side of the fault. Coal northwest of the Gulf fault, which is near the coal outcrop, is generally too badly disturbed by faults and intrusions to be mineable. The future of the coal mining industry in the Deep River field depends upon the successful development of the coal resources in the down-faulted block between the Gulf and Deep River faults." (Reinemund, 1952). Based on a 65 percent recovery, the reserves of recoverable coal in the Deep River field are estimated at 70,998,000 tons. Of this amount 32,873,000 tons are in beds from 14 inches to 24 inches thick, 26,230,000 tons are in beds from 36 inches thick, and 11,895,000 tons are in beds more than 36 inches thick. The Cumnock seam is estimated to contain 65,456,000 tons of the total estimated recoverable reserve.

Coal in the Deep River field is of a highly volatile bituminous nature except near diabase intrusives where it has been altered to semianthracite, anthracite, and coke. There are two principal coal seams, the Cumnock and Gulf. The Cumnock is 3 to 4 feet thick, and its coal has fixed carbon contents ranging from 53 percent to 60 percent, sulphur from 1 percent to 4 percent, ash from 6 to 16 percent, and heat ratings from 12,000 B. t. u. to 14,000 B. t. u. The Gulf seam is 30 to 40 feet below the Cumnock. It is generally less than 2 feet thick and in most cases is not of mineable quality.

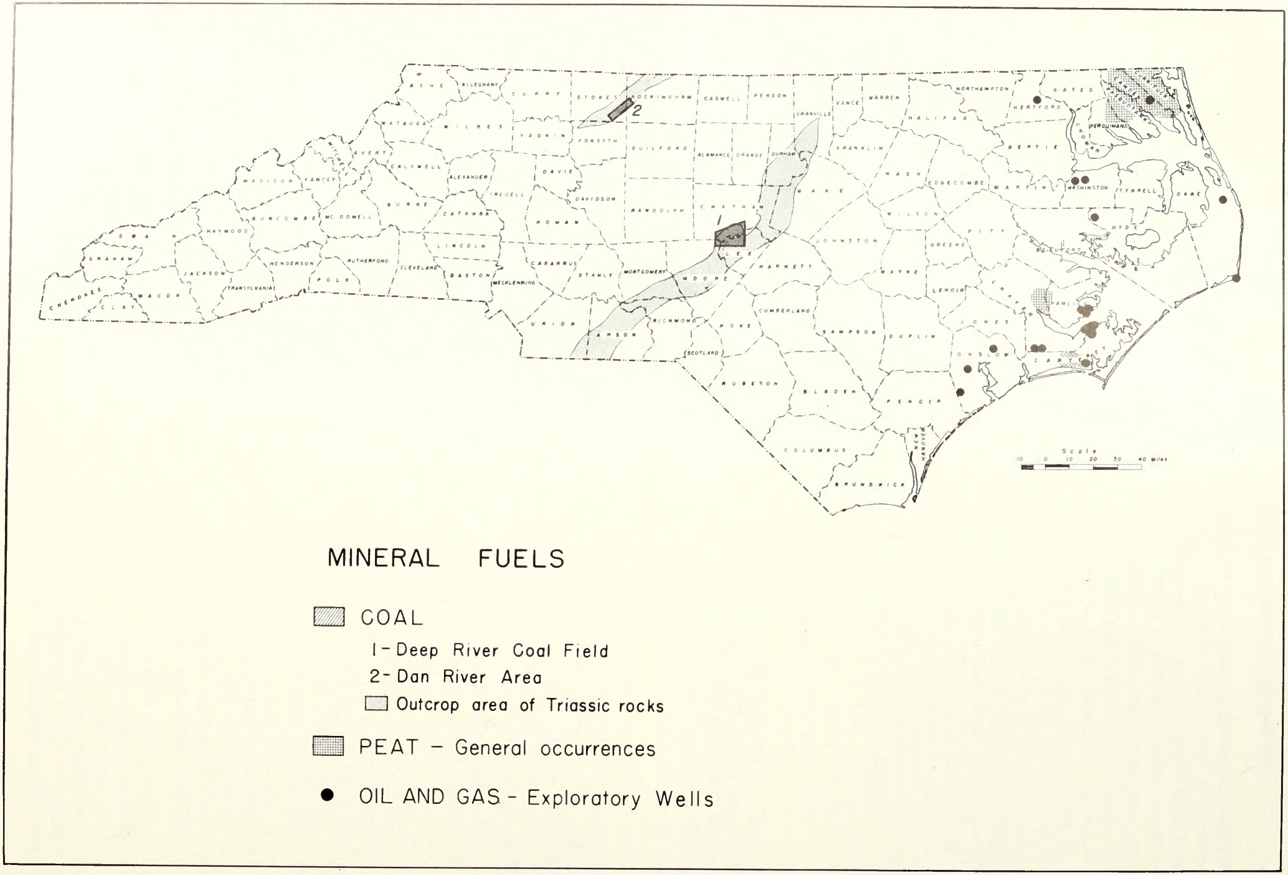

FIGURE 23. MINERAL FUELS

Coal from the Cumnock seam is of excellent quality for coking, but its sulphur content is too high for metallurgical use. Tests carried out by the United States Bureau of Mines to determine the coking properties of the coal and available byproducts showed the yield of coke, gas, and tar are comparable to those for coals of like rank from other coal fields. Analyses of the washed coals and results of tests are given below.

PROXIMATE AND ULTIMATE ANALYSES OF WASHED COAL AND COKE

	Percent Washed Coal	*Percent Coke*
Moisture	1.0	0.5
Volatile Matter	33.0	3.8
Fixed Carbon	59.6	87.2
Ash	6.4	8.5
Hydrogen	5.2	1.2
Carbon	78.9	86.0
Nitrogen	2.1	2.0
Oxygen	5.8	1.0
Sulphur	1.6	1.3
B. t. u.	14,220	13,350

Final coking temperature	775° to 800° C. (1427°-1472° F.)
Weight of charge	15 pounds
Coke yield	75 percent of charge
Gas yield	8,000 cu. ft. per ton of coal
Ammonium sulphate	23 pounds per ton of coal
Tar (dehydrated)	12.0 percent of coal charged or 22 gallons per ton of coke.

Coal was known to occur in the Deep River area prior to 1775 and was being mined on a small scale from the Horton Mine during the Revolutionary War. In 1852, the Egypt (later Cumnock) Mine was opened by a 430-foot shaft and produced intermittently until 1929. Many smaller mines and pits were also active during this period. The Carolina Mine at Farmville was started in 1921 and was worked at intervals until 1930. It was reopened in 1942 and operated until 1945 and again from 1947 until 1950. The Murchison, Deep River, and Gardner Mines were operated between 1930 and 1940, and the McIver Mine was opened briefly in 1942. It is estimated that the total amount of coal mined or lost in the Deep River coal field since the Revolutionary War is approximately 1,065,000 tons.

During the period 1946-1953 there was considerable exploratory work in the Deep River field, and an effort to develop the Carolina Mine by a major coal company. Between April 1944 and November 1948, the United States Bureau of Mines completed 8 drill holes, totaling 11,890 feet, in the area. In the summer of 1945, the Walter Bledsoe Company drilled 10 holes and acquired approximately 2,000 acres of what appeared to be the most mineable coal, including the old Carolina Mine. The Raleigh Mining Company was formed to carry out exploratory and development work, and mining was begun at the Carolina Mine in the fall of 1947. Because of the faulted condition of the formations approximately 800 feet of hoisting slope and 300 feet of return airways were lined with semicircular reinforced steel lining. The slope and entries off the slope were developed for rail transportation. Mining was by room and pillar methods, the coal being loaded on shaking conveyors in the rooms. During 1949, approximately 14,000 tons were produced. Since most of the developmental work was done paralleling the faulted zone, considerable difficulty was encountered in minng, and the operation ceased in 1952. Much of the mine's output during this period was used by Carolina Power and Light Company in steam generating plants.

Dan River Coal Field: The Dan River coal field lies along Dan River and its tributary Town Fork in Stokes and Rockingham Counties and extends from near Germanton northeastward to the Leaksville-Spray area. Most of the prospects along the outcrop area are near Walnut Cove, although prospecting has been carried out at various localities along the belt.

The first record of the existence of coal in this part of the State was in 1824, in a report by the State Geologist. Since its discovery there have been several attempts to mine this coal, but none were successful.

Between 1891 and 1892, the North Carolina Geological Survey drilled 2 holes, totaling 1,112 feet, in the Walnut Cove area, but no valuable beds of coal were encountered and the project was abandoned. In 1907, a diamond-drill hole about 30 feet deep was drilled and a slope driven on a thin bed of coal, but no commercial coal was found. The United States Geological Survey made a detailed investigation of the area in 1910, and results were published as Bulletin 471-B of the survey. Conclusions reached as a result of these studies are: "After a thorough and careful examination of the Triassic beds . . . the conclusion is reached there that there is no reason to expect to find commercially valuable coal beds in this district. The beds of semi-anthracite . . are only a few inches thick and of small lateral extent." There have been no attempts to develop coal in the Dan River area since this report. There has been some interest in using the black carbonaceous shales for certain fertilizer purposes.

Other Localities: Minor amounts of coal have been found at numerous localities in the main Triassic belt of rocks. Eleven miles east of Pittsboro and 3 miles southeast of Seaforth, on U. S. Highway 64, coal was encountered at a depth of 30 feet in a well on the John Goodwin farm. Geologists of the United States Geological Survey visited the occurrence in June 1947 and reported the seam to be about 11 inches thick and to be of little commercial value. Several minor occurrences of coal are present in western Richmond and southwestern Moore Counties, but these are of little importance.

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PEAT

Peat is formed by the growth and decay of grasses, sphagnum, and other plants in moist places and represents the first stages in the formation of coal. Its vegetable structure is generally visible to the naked eye, and it contains a large part of the carbon in the original vegetable matter.

In the United States most of the peat produced is used for soil improvement. Some nitrogen-rich varieties are used in preparing mixed fertilizers. It is also used for packing, deodorizing, and disinfecting. In many foreign countries peat is an important fuel. During 1951, about 75 percent of domestic production was for soil improvement, 19 percent was sold as a filler in mixed fertilizers, and 8 percent was consumed in other uses.

In the Coastal Plain of North Carolina there are many swamps and lagoons in which considerable amounts of peat occur, some deposits being of possible commercial value. One of the largest occurrences is the Dismal Swamp area, lying partly in North Carolina and partly in Virginia. In the North Carolina portion, deposits of peat are found in Perquimans, Pasquotank, Camden, and Currituck Counties. Analyses of samples from Currituck County are as follows:

Proximate			*Ultimate*		
Moisture	8.23	%	Ash	6.18	6.73%
Volatile matter	52.05	56.72	Sulphur	0.26	0.28
Fixed Carbon	33.54	36.55	Nitrogen	1.60	1.74

In the immediate vicinity of Elizabeth City there is an area of good-grade peat, averaging from 14 to 18 feet thick. Deposits of peat northeast of New Bern were worked from 1918 to 1922. A large area of peat occurs adjacent to the Atlantic Coast Line Railroad in Sampson County. Analyses of this peat are as follows:

Proximate	
Moisture	11.25%
Volatile Matter	52.15
Fixed Carbon	34.90
Ash	1.70

Ultimate	
Nitrogen	1.09%
P_2O_5	trace
K_2O	0.04
Moisture	10.05
Ash	1.7

Various companies mined peat during and following World War I, but no production has been recorded since 1922. Most of the peat mined in North Carolina was used in the preparation of mixed fertilizers.

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EXPLORATION FOR PETROLEUM AND NATURAL GAS

North Carolina has not been considered a particularly favorable area for the occurrence of oil or gas in commercial quantities. However, since World War II, more detailed information concerning the geology of the subsurface formations of the Coastal Plain has been made available, and interest has increased in the possibilities of finding oil and gas in that area. From 1945 to 1954, 20 exploratory wells were drilled; and, although no oil or gas was reported, the geologic information obtained during drilling and from subsequent surface investigations indicate that North Carolina warrants further consideration of its oil and gas potentialities.

GEOLOGIC CONSIDERATIONS

Most of the western two-thirds of North Carolina is underlain by igneous and metamorphic rocks which are not considered as having oil-bearing capabilities. There are two belts of Triassic sediments which are exceptions. One is about 8 miles wide and 40 miles long and extends from near Winston-Salem to the Virginia state line, and the other is approximately 12 miles wide and 140 miles long and extends along the eastern part of the Piedmont Plateau from near Oxford in Granville County southwestward into South Carolina. These sediments consist of sandstones, conglomerates, and shales of continental origin. They have been faulted badly and intruded extensively by igneous dikes and sills. Although some of the shales are known to be oil-bearing, the Triassic rocks in North Carolina are not considered potential sources of petroleum.

The eastern third or Coastal Plain area of the state is underlain by unconsolidated sands, clays, and marls, which form a wedge-shaped block of sediments extending from near the Fall Zone eastward to beyond the present coastline. Near the western limits, the sediments are very thin, but they thicken gradually toward the east, being nearly 10,000 feet thick at Cape Hatteras. Most of the formations have very gentle dips and individual beds are not consistent, conditions considered not favorable for the accumulation of large amounts of oil or gas. However, recent detailed geological studies have indicated that in some parts of the Coastal Plain underlying structures may not be as simple as had been supposed, thus increasing the possibilities of the presence of local traps. A considerable amount of exploration must be done before the oil and gas possibilities of the Coastal Plain can be determined.

HISTORY OF EXPLORATION

Since some of the Coastal Plain sediments have been correlated with formations of similar ages to the southwest in which oil and gas are known to occur, they are, therefore, the most logical to be investigated in North Carolina, and most of the exploratory work has been confined to them.

The earliest recorded exploration for oil in North Carolina was in 1911, when the East Coast Drilling Company drilled 3 holes about 3.5 miles northeast of Coinjock, Currituck County. It is reported the holes reached depths of 377, 764, and 855 feet, respectively, but records of the operation are vague.

In 1924 and 1925, the Great Lake Drilling Company drilled a well on the southern shore of Ellis Lake, about 5 miles west of Havelock, Craven County. This well, known as Great Lake No. 2, was logged by W. C.

Mansfield of the United States Geological Survey, and the report was published as Economic Paper 58 of the North Carolina Department of Conservation and Development. It was drilled to a total depth of 2,404 feet and is reported to have reached the crystalline basement at 2,318 feet. The well was abandoned as a dry hole with no evidence of oil or gas.

In 1927, F. C. Vilbrandt described oil-bearing shales in the Triassic formations along the Deep River valley in a report published as Economic Paper 59 of the North Carolina Department of Conservation and Development. The shales are reported to yield from 11 to 45 gallons of shale oil per ton, or an average of 23 gallons; 8.46 pounds of ammonium sulphate; and 1,900 cubic feet of gas. No further work has been done on these shales. However, 17 diamond-drill holes have been drilled in the Deep River Coal Field in recent years but have shown no commercial oil or gas and have indicated no satisfactory structures to trap oil or gas.

Following the drilling of the Great Lake No. 2 well in 1925, there was little interest in exploration in North Carolina until the early 1940's, when the possibilities of the Atlantic Coastal Plain were again considered. Much of the interest was prompted by the discovery of oil in Florida. By 1944, several major oil companies and a local company were actively engaged in exploration in North Carolina. State-controlled lands north of a line drawn between Washington, Beaufort County, and Cape Hatteras, Dare County, and east of the 77 Meridian were leased to Standard Oil Company of New Jersey. State lands south of a line from New Bern, Craven County, to Ocracoke Inlet were leased to the Coastal Plains Company of Kinston, North Carolina. Private lands were leased by most of the major companies and by three local companies: Coastal Plains Company and Tidewater Petroleum Company of Kinston, and the Carolina Petroleum Company of Durham.

Early in 1944, the Coastal Plains Company began geophysical surveys and contracted with F. L. Karston to drill Laughton No. 1 well on the south bank of Newport River, 3 miles north of Morehead City in Carteret County. This well was started in May 1945, was drilled to a depth of 4,044 feet, encountering basement rocks at 4,030 feet. It was abandoned in June 1945.

The Carolina Petroleum Company began drilling near Merrimon, Carteret County, in 1946, and drilled five holes. The Guy M. Carraway No. 1, abandoned at 4,069 feet in July 1946, cut the basement granite at 4,054 feet. The Nita Carraway No. 1 reached the granite at 4,120 feet and was abandoned in August 1946, with a total depth of 4,126 feet. The D. L. Phillips No. 1 cut the granite at 3,946 feet and was abandoned in September 1946, at a total depth of 3,964 feet. The H. B. Salters No. 1 cut the granite at 3,955 feet and was abandoned in October 1946, at a total depth of 3,963 feet. Sidewall samples taken from this well by the Schlumberger Well Surveying Corporation were reported to give slight odors of oil at several places, but drill stem tests failed to produce any oil show. The John Wallace No. 1 cut the granite at 4,020 feet and was abandoned in December 1946, at a total depth of 4,025 feet. Slight evidence of oil is reported for this hole.

The Charles Bryan No. 1 was drilled by the Carolina Petroleum Company about 1.5 miles east of the Great Lake Drilling Company's hole on Ellis Lake and about 4.5 miles west of Havelock, Craven County. This hole cut the basement granite at 2,408 feet and reached a total depth of 2,435. It was abandoned in January 1947, with no evidence of oil or gas. The North Carolina Pulpwood No. 1 was drilled about 1 mile west of the town of Pamlico, Pamlico County. This hole reached a total depth of 3,667 feet and cut the basement (slates) at 3,658 feet. It was abandoned February 25, 1947. The rig was moved 1.2 miles farther west, and the Atlas Plywood No. 1 was drilled to a depth of 3,425 feet, cutting the basement at 3,414 feet. This hole was abandoned on March 21, 1947.

In 1944, the Standard Oil Company of New Jersey carried out extensive geophysical surveys in the state and on December 1, 1945, spudded its Hatteras Light Well No. 1, located 1,696 feet southwest of the old lighthouse on Cape Hatteras, Dare County. This well was abandoned as a dry hole on July 19, 1945. Its total depth was 10,054 feet, the top of the basement being at 9,978 feet. A second well, North Carolina Esso No. 2 was started on January 7, 1947. This well was located in the Pamlico Sound, approximately 11 miles south of Wanchese and 3.5 miles west-northwest of Pea Island Coast Guard Station. It was drilled to a depth of 6,410 feet and did not encounter basement crystallines, which were estimated to be at a depth of 8,000 feet. The well was abandoned March 13, 1947.

Pam-Beau Drilling Company began the Basemore No. 1 well in 1948. It was located on Wiccacon Creek near Harrellsville, Hertford County. This well was abandoned in 1949 at a depth of approximately 1,200 feet and apparently was in crystalline rocks.

In 1950, the Coastal Area Development Company drilled two wells north of Holly Ridge in Onslow County. Cadco well No. 1, located 4 miles north of Holly Ridge, was begun in May 1950 and drilled to a depth of 1,497 feet. It entered basement rocks at 1,449 feet. The well was abandoned on August 10, 1950. Cadco No. 2, located 7 miles southwest of Jacksonville and 2 miles west of Verona, Onslow County, was drilled to a depth of 1,493 feet and cut the basement at 1,343 feet. It was abandoned as a dry hole November 10, 1950.

Davidson Oil Development Company began operations in 1951 and drilled 3 holes in Washington and Carteret Counties. All bottomed in Cretaceous sediments. Roper No. 1 well, located in Washington County 5 miles southeast of Plymouth and 100 yards west of N. C. Highway 99, was completed at a depth of 2,223 on September 10, 1951. Furbee No. 1 well, located in Washington County on the lands of J. H. Furbee north of Wenona and east of Roper No. 1, was abandoned October 10, 1951, after having been drilled to a depth of 2,660 feet. The third well, Rhem No. 1, was in eastern Hyde County, one mile northwest of Ponzer and just north of the county road. This well was 3,123 feet deep when it was abandoned on November 6, 1951.

In 1953, Burton Drilling Company, acting under leases assigned by the Coastal Plains Company, drilled the Hofmann Forest No. 1 well to a depth of 1,570 feet, basement rocks being reported at 1,560 feet. This well is in Onslow County, about 5 miles north of Jacksonville. It is located one mile east-southeast of the Hofmann Forest fire tower along U. S. Highway 17. The well was abandoned in October 1953, and the rig moved to the site of Hofmann Forest No. 2 well, one mile northwest of the fire tower. As of December 1953, this well had not been started.

The Urice Drilling Company, acting for DuGrandlee Exploration Company, drilled the Foreman No. 1 well in eastern Camden County, approximately 10 miles north of Elizabeth City. This well did not enter crystalline rocks and was abandoned in October 1953, at a depth of 6,421 feet.

Samples and logs of most of the wells drilled since 1945 are on file in the offices of the Division of Mineral Resources of the North Carolina Department of Conservation and Development and are available for inspection.

Recent geologic investigations carried out by geologists of the Ground Water Branch of the United States Geological Survey in Bladen, Pender, and Columbus Counties have indicated the presence of structures heretofore not known. Paleontological work, groundwater analyses, and the presence of salt-marsh conditions in restricted areas may indicate the presence of a northeasterly trending basin in the southwestern part of Bladen County in the vicinity of Kings Bluff. Although two water wells near Wilmington have penetrated the entire section of sediments near the coast and no indications of oil or gas were found, little is known concerning details of underlying structure northwest of Wilmington. This area may warrant serious consideration for exploration in the future. More geological information and exploratory holes are necessary before final conclusions can be drawn as to the presence of commercial quantities of oil or gas in North Carolina.

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APPENDIX

THE MINING LAWS OF NORTH CAROLINA

Rules and regulations which govern the mining industry in North Carolina are safety precautions largely and are administered through the Division of Standards and Inspections of the Department of Labor. This organization maintains mine inspectors whose duties are to promote safety throughout the mining industry. Information concerning rules, regulations, and general safety recommendations as prepared by the Department of Labor is presented below.

PART I

RULES AND REGULATIONS GOVERNING MINING INDUSTRY

Purpose: The purpose of this code is to provide safety standards for the protection of the health, safety and general well being of employees engaged in the mining industry.

Authority: Under Sub-section (f) of Section 7310-h, Consolidated Statutes of North Carolina, the Division of Standards and Inspections of the Department of Labor is authorized and directed "to conduct such research and carry out such studies as will contribute to the health, safety and general well being of the working classes of the State. The findings of such investigations—shall be promulgated as rules and regulations governing work places and working conditions." Under this authority the following rules have been promulgated to safeguard the lives, limbs and health of workers in Mines.

Scope: The code is divided into two parts. Part I is mandatory. Part II is not mandatory, but is for the purpose of furnishing information and advice.

Penalty: Under Chapter 398, Public Laws of North Carolina, Session of 1939, it is provided:

"Section 1. That Chapter three hundred twelve of the Public Laws of one thousand nine hundred thirty-one be, and the same is hereby amended, by inserting a new section to be designated as Section thirteen (a) as follows:

"Section 13(a). In the event any person, firm or corporation shall, after notice by the Commisisoner of Labor, violate any of the rules or regulations promulgated under the authority of this Act or any laws amendatory hereof relating to safety devices, or measures, the Attorney General of the State, upon the request of the Commissioner of Labor, may take appropriate action in the civil courts of the State to enforce such rules and regulations. Upon request of the Attorney General, any solicitor of the State of North Carolina in whose district such rule or regulation is violated may perform the duties hereinabove required of the Attorney General."

For the modification of any of these rules and regulations the following shall be the method of procedure:

Any employer, employee or other person may file a petition with the Commissioner of Labor setting forth the rule or regulation upon which a change is desired and the reason for such a change.

Upon receipt of a petition the Commissioner will determine its merits, and, if a hearing is necessary, notice of the time and place will be given to the petitioner and to such other persons as the Commissioner may find directly interested.

DEFINITIONS

The term MINE shall mean all underground workings as excavations, shafts, tunnels, slopes, drifts, entries and all other openings, and shall include all equipment and materials connected with its operation.

The term WORKINGS shall mean all the excavated parts of a mine, those abandoned as well as the places actually being worked.

The term SHAFT shall mean a vertical opening through the strata and which is or may be used for the purpose of ventilating or drainage, or for hoisting men or materials in connection with mining operations.

The term SLOPE shall mean any inclined way or opening used for the same purpose as a shaft.

The term DRIFT shall mean any inclined way or opening wherein haulage is effected by any methods and hich is used for the same purpose as a shaft or slope.

The term OWNER or OPERATOR shall mean the person, firm or corporation who is in legal possession of mine, and as such responsible for the condition and management thereof.

The term TIMBER shall mean all wood, steel, concrete or other materials used in strengthening and suporting any part of a mine.

The term STOPE shall mean an excavation from which the ore has been removed, either above or below level, in a series of steps.

The term STANDARD RAILINGS shall mean railings not less than 42 inches in height and provided with termediate rail between the top rail and the ground or floor, and constructed in a permanent and substanial manner.

The term WINZE shall mean a steeply inclined passageway driven to connect one mine working place with nother at a lower level.

The term ADIT shall mean a nearly horizontal passage from the surface.

The term EXPLOSIVES shall mean and include any chemical compound or chemical mixture which is used blasting and so recognized by the INSTITUTE OF MAKERS OF EXPLOSIVES.

The term BARRICADED shall mean a physical barrier, either natural or artificial, around the magazine protect the life and limb of persons.

The term CLASS "A" MAGAZINE shall mean the principal magazine located outside of the mine and used r the storage of 200 pounds or more of explosives.

The term CLASS "B" MAGAZINE shall mean the magazine used for the storage of less than 200 pounds f explosives, or the magazine located in the mine and used for the storage of one day's supply of explosives.

The word SHALL where used is mandatory and SHOULD is advisory.

RULES AND REGULATIONS

I. **Means of access.** Safe means of access shall be provided to all working places.

Where ladders are used, they should be constructed in lengths not in excess of 20 feet each and they shall e erected in a staggered line with a landing between lengths. The ladders shall be of steel or suitable wood onstruction.

Where stairs are used, the treads should be at least 1 ¾ inches in thickness and the combined tread and iser distance shall not exceed 18 inches. The tread width shall not be less than 7 inches and shall be uniform width. Riser heights shall be uniform for any given stair including both top and bottom step. All stairs hall be guarded on open sides by substantial handrails. Where long flights of stairs are used, landings shall e provided not more than 30 feet apart. Landings between flights of stairs shall be a flat platform, the idth of the stairway, and not less than 3 feet in length.

1. **Mine outlets:** There shall be at least two outlets to the surface from every seam, bed or vein actually eing worked. Both outlets shall be readily accessible from every section of the mine. This provision shall e enforced without exception if any shaft, slope or drift shall have been advanced 300 feet or more from the outh. These outlets shall be separated by a stratum of not less than 100 feet in breadth underground and t the surface. It shall not be necessary for these two openings to belong to the same mine if the persons mployed have safe, ready and available means of ingress and egress.

A. **Exceptions:**

No second outlet shall be required:

(a) When opening a new mine while it is being worked for the purpose of making communications beween the two outlets.

(b) When opening a new lift or level in a mine while being worked for the purpose of making communicaon between two outlets.

2. **Lining of mine outlets:** For a distance of 30 feet beyond the surface, and at all other places where t strata are not safe, every shaft, slope and other mine opening shall be securely cased or lined.

3. **Places of refuge:** A clearance space of not less than $2\frac{1}{2}$ feet on one side of the tramway shall be mai tained at all times where mechanical haulage is used. Where such space cannot be maintained, refuge plac shall be provided at not more than 60 foot intervals, which shall afford a clearance space not less than 4 fe wide, 5 feet high and 8 feet long. The roof and sides shall be made secure, using lagging if necessary. A such places of refuge shall be conspicuously marked.

4. **Structures around mine openings:** No inflammable structure shall be erected nearer than 200 feet to a entrance; and no structure of any description shall be erected nearer than 50 feet to any mine opening unle the building plans have been approved by the Commissioner of Labor or his duly authorized representativ Nothing in these regulations shall be construed to prohibit the erection of a mechanical or electrically driv fan for ventilating purposes provided the fan is housed in non-combustible material and the air duct leadi to the opening is also built of non-combustible material. This particular rule concerning structures arou mine openings shall not apply to any shaft or slope until the work of preliminary development and subseque hoisting of material mined has commenced.

A. **Exceptions:**

This requirement shall not apply to structures erected prior to October 1, 1942.

For means of ingress and egress required for coal mines, refer to Section 6900 of Consolidated Statutes North Carolina.

II. **Fencing:** The top of each shaft, slope or incline and every intermediate level or station thereof sh be adequately fenced to prevent persons or animals from falling into them. Signs shall be placed at int vals, reading: "DANGER—KEEP OUT."

III. **Room and pillar method of mining:** When the room and pillar method of mining is engaged in, pilla of sufficient size shall be left in place to support the roof or overburden. This does not prohibit later e traction of pillars nor do pillars take the place of timbers as the rooms are advanced.

IV. **Roof inspection:** In the parts of the mine where persons are employed or travel frequently, the ro shall be kept free of loose material.

V. **Timbering:** Every shaft, incline, slope, adit, tunnel, level or drift and any working place in the mi shall be properly secured by timber.

VI. **Hoisting requirements in shafts being sunk:** Over all shafts, as they are being sunk, there shall erected not less than 20 feet above the dump landing, a substantial structure to support the sheaves a pulleys. This structure shall be erected as soon as a substantial foundation is obtained and in no case sh a shaft be sunk to a depth of more than 50 feet without such structure.

No hand powered windlass hoist, winch or derrick shall be used unless equipped with a positive means holding the load in any position.

VII. **Rules to be observed in shafts being sunk:** In a shaft or winze which is being sunk, the bucket or sl shall not be lowered directly to the bottom of the shaft where men are working, but shall be held at least feet above the bottom until the signal to lower has been given.

While shafts are being sunk, all blasts therein shall be exploded by an electric battery.

After a suspension of work and after the firing of each blast in a shaft, the bottom of the shaft shall examined and tested for gas by a competent person before the workmen are allowed to descend.

After each blast in a shaft, all loose material shall be swept down from the timbers before the workm descend.

VIII. **Haulage and hoisting:** The use of gasoline engines in mines is forbidden.

All hoists shall be equipped with an efficient brake capable of stopping and holding the loaded car at a point on the slope or shaft. Where practicable, they shall also be equipped with approved devices which w bring the hoist to rest upon failure of power and will permit lowering of the load by brakes.

Every drum used for hoisting or lowering persons in any mine shall be equipped with flanges or drum guides of sufficient dimension to allow a height of two inches above the cable at all times.

At all shafts and slopes where men are hoisted or lowered, adequate protection against overwind by means of an automatic stop or other approved device shall be provided.

The design and construction of each cage shall be such as to support safely five times the maximum dead load it will be required to carry and ten times the live load.

Every cage used for hoisting or lowering men in shaft shall be provided with a substantial cover. The entrance of each cage should be protected by a door five and one-half feet high. The sides shall be substantially enclosed to the top of the cage. There shall be an adequate number of hand holds.

All slopes or inclines in mines shall be provided with derail switches or automatic car stops near the top of the incline or slope.

The hoisting equipment shall be housed in a suitable shed or building which will furnish protection to the operator and equipment. An efficient signal system shall be provided for every hoisting engineer operating on a slope or shaft.

IX. **Boiler inspection:** Every steam boiler shall be inspected as required by the North Carolina State Boiler Inspection Law.

X. **Pressure tanks:** All compressed air tanks, cylinders, or other vessels and their safety valves and other attachments should conform to the latest A. S. M. E. Code for Unfired Pressure Vessels.

XI. **Electrical installations and fixtures:** All electrical wiring shall be strung on standard insulated supports 5 feet or more above the floor or travelway. In the event this height is not available, the wiring shall be placed on the opposite side of the haulageway from the traveling space and shall be properly guarded.

Electric circuits, equipment, frames and bed plates of generators, transformers, compensators, rheostats, motors and switches shall be effectively grounded. All metallic coverings and conduit shall be grounded.

All electric light and power lines, regardless of voltage, shall be insulated and properly strung on standard insulators.

Drop cord extension light lines shall be flexible with heavy rubber insulation, equipped with heavy wire light globe shield and hook and heavy rubber handle.

If employees are required to handle heavy and high voltage rubber covered power lines, they shall be provided with and required to wear rubber gloves and rubber boots, or electrician's shoes. The gloves should be tested at regular intervals by a competent person. Hemp rope, in lengths of 6 or 8 feet, looped over the power cable is considered a safer means of moving it.

An approved fire extinguisher should be placed near each electric motor.

The following safety rules shall be complied with in all electrical work:

Do not change any wiring or connections while the power is on. All electrical work, when possible, shall be done on days when the plant is not in operation. Whenever circuits are opened for repairs, alterations or examinations, the disconnecting switches shall also be opened. The workman responsible for having the circuit opened shall place on a controlling switch a tag bearing his name and a notice that the switch shall not be closed until the tag is removed; also, the switch should be locked out with the workman holding the key. No person other than the workman tagging the switch, shall be allowed to remove the tag. Whenever it becomes necessary for the person tagging a switch to leave before the work is completed, he shall go to the switch, accompanied by the man who is to assume the responsibility, and remove the tag and unlock the switch; his successor shall then lock the switch and attach a similar tag to the switch before he begins work.

XII. **Guards:** All belts, gears, pulleys, shafts, wheels and other moving parts of machinery shall be adequately guarded. If the guards are removed for any reason, they should be replaced before the machine is put in motion.

XIII. **Protective clothing and equipment:** All persons working around or subjected to flying particles of hard materials shall be provided with and required to wear goggles which afford adequate protection.

All persons working underground shall wear protective hats or caps.

Safety shoes should be worn by all persons handling materials.

XIV. **Scaffolds and platforms:** All scaffolds and platforms shall be safely constructed.

XV. **Ventilation:** An adequate supply of pure air shall be provided, and shall be circulated to all worki places underground. When underground workings have reached a depth or distance of 500 feet from t surface or opening, some approved means of mechanical ventilation will be required.

For ventilation required for coal mines, refer to Sections 6902, 6903 and 6904 of the Consolidated Statut of North Carolina.

XVI. **Dust control:** Where harmful dust conditions exist in work places, there shall be preventive or cont measures installed in such work places that will effectively reduce the dust concentration to a safe limit defined by the Commissioner of Labor.

Wherever in the opinion of the legal representative or authorized agent of the State Department of Lab there exists atmospheric dust conditions that exceed the safe limits or threshold concentrations as defined the State Board of Health, or which are detrimental to the health of the worker as confirmed by technic studies of the State Board of Health, or by the State Department of Labor, there shall be installed preventi or protective measures that will reduce the hazardous dust concentrations to safe limits, or otherwise sa guard the health of the worker. The preventive or protective measures proposed must have the approval the State Department of Labor prior to installation.

Experience has shown that by proper methods of wet drilling and other wet methods, dust can be controll very satisfactorily under most conditions. Muck and mineral piles should be effectively wet down with wat before loading operations are begun and as often as necessary during handling.

XVII. **Mine map:** An accurate map or plan of the workings or excavations of a mine shall be provided a drawn not less than 200 feet to the inch. One copy of the map shall be kept at the mine and shall be availab to the Commissioner of Labor, or his duly authorized representative, at all times.

XVIII. **Checking in and out of mine:** A check-board shall be provided and all persons entering or leavi the mine shall check in and out.

XIX. **Drainage:** Adequate equipment for drainage of all working places shall be provided.

XX. **First aid supplies—first aid training:** At each mine there shall be maintained—conveniently locat where employees may have individual access to them in case of accident or injury—a tight fitting first a cabinet. The cabinet shall be marked "FIRST AID" and contain the following supplies:

FIRST AID SUPPLIES

Instruments

1 pair scissors
thumb forceps
tourniquet
graduated medicine glass

Drugs

2 oz. aromatic spirits of ammonia
2 oz. 4 percent boric acid
2 oz. alcoholic iodine solution, half strength (for external use)
2—3 oz. collapsible tubes of bicarbonate of soda mixed with vaseline (3 percent for burns)
2 oz. castor oil (for eye injuries)

Dressings

1 doz. assorted sizes sterile gauze bandages
1 spool Z. O. adhesive plaster, 1 inch by 5 yards
3—½ oz. packages of absorbent cotton
3—1 yard packages of sterile gauze
Splints of assorted sizes for fractures
Wooden applicators wound with cotton
Wooden tongue depressors

The Department of Labor accepts standard unit type kits as complying with the first aid regulations.

There shall be maintained one stretcher and blanket properly stored in a convenient storage marked ‘STRETCHER”.

At least one person who has been properly trained in first aid application shall be on duty at all times. If irst aid training is desired, application should be made to the Department of Labor.

XXI. **Explosives—safety in transportation, handling, storage and use:**

(1) **Location of magazines:** Where possible all magazines in which explosives or detonators are kept or tored, and erected after October 1, 1942, shall be located at a distance from buildings, railroads, and high-vays in conformity with the QUANTITY AND DISTANCE TABLE FOR BARRICADED MAGAZINES. Vhere such magazines are not barricaded, the distance shown in the table shall be doubled.

The table of distances will be found in Part II of this code.

(2) **Construction of magazines:** The principal magazine, referred to as CLASS “A” MAGAZINE shall be ullet and fire resistant, weatherproof, dry and well ventilated.

The CLASS “B” MAGAZINE shall be a substantially constructed wooden box marked properly and equipped vith proper lock. It shall be located so as to be safe from fire or from flying stones. If the daily supply nagazine is close to buildings or highways, it must be made bulletproof by using a double box with a six nch space between the outer and inner walls and the space filled with sand, clay or mine waste or “fines”. he exterior of the magazine must be covered with No. 26 gauge galvanized iron or its equivalent.

(3) **Marking the magazine:** At a distance of not less than six feet and at right angles to the sides of the nagazine a sign shall be posted with the words “EXPLOSIVES—KEEP AWAY” printed in letters not less han six inches high.

(4) **Separate storage for detonators:** Blasting caps shall not be stored in the same magazine with dyna-nite, powder, or other high explosives, but shall be stored in a magazine of similar construction to that of the igh explosive magazine.

(5) **Opening packages of explosives:** Cases of dynamite, black blasting powder or other high explosives hall not be opened in the magazines.

Wooden, fibre or hard rubber tools shall be used in opening cases of high explosives.

(6) **Transporting explosives:** All blasting caps, detonators and electric squibs used in a day’s work shall e carried into the mine in the containers in which originally packed by the manufacturer; except that a uantity less than one full container shall be carried to the place it is to be used in wooden or fibre boxes vithout interior exposed nails or other fastenings. Separate containers shall be used for explosives and etonators.

(7) **Warning signals:** A warning signal such as a whistle, siren or bell shall be sounded before and after ach blast. Sufficient time shall be allowed for persons in the danger area to retire to a safe place. Persons hall not be permitted to stand in exposed places while a blast is being made, nor shall any person return to he place of the blast until the return signal has been given by the shot firer.

Where travelways approach the danger area, a designated person shall be stationed in a safe location for he purpose of stopping traffic. If there are residences located within the danger zone, the inhabitants shall e advised as to the time of the blast.

(8) **Firing in gassy mines:** In all mines where locked safety lamps are used, an adequate test for gaseous onditions shall be made and no blast shall be fired until test has been made and found to be safe.

(9) **Examination of face:** After the firing of every blast and before commencing work on the face or im-ediately adjacent thereto, a competent person shall examine the face, sides and roof of each working place at has been shot. No person except the person making the examination shall enter any working face until ch examination has been made.

(10) **Loading holes:** 1. Primary blasts: No work should be carried on immediately in front of the section eing loaded. The number of persons in the immediate vicinity of a hole being loaded shall be kept to a inimum.

2. Hammer drill holes: Only wooden tamping poles shall be used. Loading shall be done with great ca Smoking or carrying lights while handling explosives is strictly forbidden. The use of black powder a high explosives in the same hole is prohibited.

Never force a primer cartridge into a drill hole. Either remove the obstruction or make up a smaller prim which can be inserted without force.

Explosives should not be handled during an electric storm. Bore holes for electric firing should not be co nected or loaded during the approach of a thunderstorm. If charges are already loaded and connected, persons should be kept a safe distance from them while the storm is in progress. If necessary to leave ov night, the ends of the wires should be twisted together and coiled.

3. Block holes: Where fuse and cap are used to explode charges, the cap shall be attached to the fuse means of a crimper. Caps shall not be crimped within a dynamite magazine or within ten feet of such magazine.

Any brand of fuse not previously used shall be tested by the blaster to determine its rate of burning bef it is used in actual work.

Only freshly cut ends of fuse shall be inserted into blasting caps. When starting to use a new coil, inch shall be cut from the end and discarded.

In lighting shots primed with fuse and cap, a signal device shall be used to notify the men when to cea lighting and to return to the shelter provided for them.

(11) **Firing blasts:** Rubber covered, No. 14 copper leading wire, or its equivalent, is recommended for firi blasts. All untaped connections shall be kept off the ground and care shall be taken to keep all wires fr contact with pipe lines, rails, wire fences, etc.

A person shall be stationed at the firing switch or blasting machine and connections shall not be made the leading wires until just prior to the time of the blast and shall be in the presence or under the direction the blaster. For a primary blast a two minute signal shall be sounded five minutes prior to the blast.

(12) **Defective explosives:** Defective caps or explosives shall be stored separate and apart from other plosives, and plainly marked "DEFECTIVE". It is recommended that when such products are found, factory representative of the manufacturer, or other competent person, destroy them. This is a very p ticular job and should not be attempted by anyone not familiar with its hazards.

XXII. **Report of accidents:** The report of all serious or fatal accidents is required under Section 6906 of Consolidated Statutes of North Carolina, as amended by C. 223 Public Laws of 1939. Accident report bla will be furnished on request.

XXIII. **General safety:** All unsafe or dangerous conditions in any part of the mine and accidents occurr in the course of the operations shall be promptly reported.

Talking to the hoistman or signalman while they are on duty shall not be permitted.

Mushroom heads on chisels, points and traces shall be properly conditioned before using.

Every injury should be reported immediately to the foreman and the proper first aid given before the ployee returns to work.

Safety meetings should be held weekly for all supervisors and at least monthly for all employees.

Underground workings and the surface should be connected by telephone.

PART II

GENERAL SAFETY RECOMMENDATIONS

1. **Means of access:** Where a single shaft affords the regular means of ingress and egress to persons ployed underground, such shaft shall be divided into at least two compartments by solid partitions. One these compartments shall be set aside for use as a ladderway and no hoisting conveyance shall be allo therein.

In the construction of ladders, stringers shall not be less than 2 inches by 4 inches, notched or mortised full depth into the stringers. The width of the ladder shall not be less than 12 inches, with the rungs uniformly spaced and not more than 14 inches center to center. The minimum clearance back of the rungs should not be less than 6½ inches from any fixed object.

All fixed ladders shall be of sufficient length to extend at least 3 feet above the landings. The top of the ladder shall be firmly secured to the ledge.

In stopes with square sets, the working floor shall be closely and securely lagged over. Openings in the floors shall be protected by standard railings.

II. **Timbering:** No split props shall be permitted in any mine to support the sides or roof unless it is a cross-section equal to or greater than a six inch round or square prop.

No hemlock, chestnut, popular, cypress, or other soft, brittle, or elastic wood shall be used as collars in any mine.

Mud sills of ample size shall be used to support the legs, collars and lagging when the floor of the drift or gangway is soft. All legs for timber shall be set in notches in the mud sill. The notch or juggle cut in the sill shall not be less than one inch nor more than one-third the thickness of the sill. If the floor is composed of solid material and a mud sill is not required, the legs shall be properly hitched in the bottom to prevent the slides from pushing the timber.

Where miners are undercutting coal with picks, they shall be protected by props and breast caps, or head-blocks, set not more than three feet from the face and not more than six feet apart.

Attention is called to the fact that rot will spread from old timbering to new when the old rotten members are left in place. They should be removed as a matter of economy as well as safety. The life of timber can be prolonged considerably by the use of a preservative, such as creosote, coal tar, or other products, and this should be given due consideration before timbering is begun.

III. **Hoisting requirements in shafts being sunk:** Shafts that are being sunk shall be equipped with guides to prevent the bucket from swinging while ascending or descending. Such guides shall be maintained at a distance of not more than 75 feet from the bottom of the shaft until it has been completed. This requirement shall not apply to shafts 100 feet or less in depth. Hoisting by buckets shall not be done in shafts of a greater depth than 200 feet.

All material elevated from shafts as they are being sunk shall not be raised except in a bucket or on a cage, and such bucket or cage must be connected to the cable or chain by a safety hook or clevis, or other approved attachment.

Not more than four persons shall be hoisted or lowered at the same time on a bucket. Standing on the sides shall not be permitted while the bucket is in motion. No person shall ride on a loaded bucket at any time.

No bucket shall be allowed to leave the top or bottom of any shaft or winze until the workman in charge has steadied it.

No person shall be permitted to do any work in a shaft when drillers or muckers are working at the bottom of the shaft.

IV. **Haulage and hoisting:** The signal code in use shall be posted in the engine room and other places where signals are given within easy sight of the hoisting engineer. The signal code shall be printed in heavy plain type.

The following code of signals is used by most of the operating mines in the United States and is recommended:

Signals From Shaft or Slope to Hoist Engineer

a. When the hoist is at rest	1 bell or signal	HOIST
b. When the hoist is in motion	1 bell or signal	STOP
c. When the hoist is at rest	2 bells or signals	LOWER
d. When the hoist is at rest	3 bells or signals	MEN READY TO GET ON CAGE OR SKIP

Signals From Hoist Engineer to Shaft or Slope

a. 3 bells--MEN CAN GET ON CAGE OR SKIP
b. 4 bells--SEND UP EMPTY CAGE OR SKIP

Additional signals may be added when required for such as BLASTING, ACCIDENTS, etc.

Every hoisting engineer should be provided with an indicator in order to determine when the load is a proaching the top or bottom of a slope, shaft or any level.

No person shall ride upon or against any loaded car or cage, on any shaft, slope or haulageway.

Shelter or safety holes shall be provided at the bottom of all shafts and slopes and kept free from obstru tions to enable persons at the bottom of the shaft or slope to escape readily in case of danger.

The head frames or structure used for supporting the cage, skip, or trip, shall be so designed that it w withstand a greater load than the calculated breaking strength of the hoisting ropes or rope attachments. platform with standard railings and toe board shall be provided at the head sheaves and a safe railed stai way or standard ladder leading thereto.

V. **Precautions to be observed in the use of safety lamps:**

1. Be sure that the lamp is locked before being taken into the mine.

2. Examine it carefully yourself to see that it is in good condition, even if it has passed the lamp inspecto

3. Do not set your lamp on the bottom of the mine. It may be accidentally upset and extinguished a the glass globe may be broken. It is safer to hang the lamp on a timber by a stout nail.

4. When testing for gas, be careful to prevent dripping water from striking the glass globe.

5. When gas flames up in your lamp, withdraw the lamp slowly and carefully. If the flame goes out, r tire to fresh air before attempting to relight it.

A report of all gas examinations shall be kept in a book provided for that purpose. Each report shall made immediately after the examination is made. Each report shall give the date and hour at which su examination was made and shall be signed by the person making the examination. Each working place sh be marked and dated at the time of examination.

The mine superintendent or foreman shall be responsible for shutting down all workings in which accu ulation of gas encountered cannot be sufficiently diluted, rendered harmless and swept away by existing ve tilation equipment. Every person, except those who may be required to remove the danger, shall be wit drawn from or prevented from entering each working and no person shall be allowed to return to wo therein until an examination has been effected by a competent person and the workings reported safe for hi A report of all facts in such case shall be made to the Commissioner of Labor. Signs marked "DANGE OUS—KEEP OUT" shall be placed at all entrances to the working closed on account of gas.

When workings are carried to a point within one-half mile or less of a suspected worked out or abandon gas area, there shall be maintained at least twenty feet in advance of each working head one drill hole n to exceed two inches in diameter.

VI. **Test hole for water:** When approach is made to an area likely to contain an accumulation of wat working places shall not exceed twelve feet in width. At a distance of not less than twenty feet in advan of such working there shall be at least one drill hole of no more than two inches in diameter.

VII. **Explosives—safety in transportation, handling, storage and use:**

1. **Quantity and distance table for barricaded magazines:**

AMERICAN TABLE OF DISTANCES

1919 REVISION

Blasting and Electric Blasting Caps		Other Explosives		Inhabited	Public	Public
Number Over	Number Not Over	Pounds Over	Pounds Not Over	Buildings Barricaded* (Feet)	Railway Barricaded* (Feet)	Highway Barricaded* (Feet)
1,000	5,000	--------	--------	15	10	5
5,000	10,000	--------	--------	30	20	10
10,000	20,000	--------	--------	60	35	18
20,000	25,000	--------	50	73	45	23
25,000	50,000	50	100	120	70	35
50,000	100,000	100	200	180	110	55
100,000	150,000	200	300	260	155	75
150,000	200,000	300	400	320	190	95
200,000	250,000	400	500	360	215	110
250,000	300,000	500	600	400	240	120
300,000	350,000	600	700	430	260	130
350,000	400,000	700	800	460	275	140
400,000	450,000	800	900	490	295	150
450,000	500,000	900	1,000	510	305	155
500,000	750,000	1,000	1,500	530	320	160
750,000	1,000,000	1,500	2,000	600	360	180
1,000,000	1,500,000	2,000	3,000	650	390	195
1,500,000	2,000,000	3,000	4,000	710	425	210
2,000,000	2,500,000	4,000	5,000	750	450	225
2,500,000	3,000,000	5,000	6,000	780	470	235
3,000,000	3,500,000	6,000	7,000	805	485	245
3,500,000	4,000,000	7,000	8,000	830	500	250
4,000,000	4,500,000	8,000	9,000	850	510	255
4,500,000	5,000,000	9,000	10,000	870	520	260
5,000,000	7,500,000	10,000	15,000	890	535	265
7,500,000	10,000,000	15,000	20,000	975	585	290
10,000,000	12,500,000	20,000	25,000	1,055	635	315
12,500,000	15,000,000	25,000	30,000	1,130	680	340
15,000,000	17,500,000	30,000	35,000	1,205	725	360
17,500,000	20,000,000	35,000	40,000	1,275	765	380

* Barricaded, as here used, signifies that the building containing explosives is screened from other buildings, railways or from highways by either natural or artificial barriers. Where such barriers do not exist, distances should be doubled.

2. **Additional safety precautions in handling explosives**: Magazines shall be ventilated and the openings for entilation shall be so screened that sparks may not enter.

Magazine keys shall be in charge of a person especially appointed for the purpose, who shall be responsible or its conditions and see that it is kept closed.

Smoking, naked light or any source of heat in magazines is prohibited.

If leaks develop in magazine roof or walls, they shall be repaired at once.

When black blasting powder and dynamite are both stored in one magazine, store each explosive separately.

Unused dynamite and caps shall be taken to the permanent storage magazine at the end of each day.

Dynamite boxes shall be laid flat, top side up. Powder shall be stored with kegs standing on end, bungs own or on sides, "seams" down. Corresponding grades and brands shall be stored together in such a manner that brand and grade marks will show. All stock shall be stored so as to be easily counted and check and so the oldest stocks can be delivered and used first.

Magazine floors should be swept regularly and kept clean. Good housekeeping in magazines shall be quired at all times.

Rules and regulations for proper storage, handling and transportation of explosives should be placed on t inside wall of every explosive magazine. Your manufacturer of explosives will gladly furnish these on quest.

Make frequent inspections around the magazines and promptly remove dirt, leaves or other debris whi may have filled up ditches, drains or ventilators.

Empty dynamite boxes previously used for high explosives may be dangerous. Examine them carefu for stains and if they are stained, they should be destroyed and not used for other purposes.

"Adobe" or "mud-cap" blasting is inefficient and hazardous.

VIII. **Bulletin boards**: Suggested designs of bulletin boards may be had from the Department of Labor request.

Neat and attractive bulletin boards, properly placed, are essential in maintaining the interest of all wo ers in accident prevention work. Frequent changes of bulletins should be made. Good material for bulle boards consist of safety bulletins, safety rules, safety posters and slogans, photographs, cartoons, exhib of unsafe tools, broken goggles, crushed hard or safety hats and safety shoes, newspaper accounts of ac dents, etc.

IX. **Sanitation**: Standard approved plans for sanitary surface pit toilets may be secured from the St Board of Health or the Department of Labor on request.

For sanitary drinking water facilities, tight fitting milk cans, with faucet attached and individual cups w satisfactorily fulfill this requirement.

X. **General safety**: If cars have to be handled by hand, they should be pushed not pulled.

All electric switches should be operated from an insulated platform.

All electric control switches should be plainly marked, with the name of the machine which it controls.

All electric switches located in wet places shall be mounted in approved weatherproof switch boxes.

Men should be trained in the proper method of lifting and carrying material.

The proper equipment should be provided for handling material.

REGULATIONS GOVERNING DRILLING FOR OIL AND GAS

As a result of widespread prospecting for oil and natural gas in Eastern North Carolina immediately following World War II, the General Assembly of 1945 passed certain laws relating to exploratory drilling and production. These laws may be found in the General Statutes of North Carolina as Parts 1 and 2 of Article 27, Subchapter V., Chapter 113. Since Part 2 is a conservation act and becomes effective only after the discovery of oil and/or gas in commercial amounts, it is not presented here. Part 1, which regulates drilling and plugging of abandoned holes, follows:

§113-378. **Persons drilling for oil or gas to register and furnish bond.**—Any person, firm or corporation before making any drilling exploration in this State for oil or natural gas shall register with the Department of Conservation and Development or such State agency as hereafter may be established to control the conservation of oil or gas in this State. To provide for such registration the drilling operator must furnish the name and address of such person, firm or corporation, and the location of the proposed drilling operations, and file with the aforesaid Department of Conservation and Development a bond in the amount of two thousand five hundred dollars ($2,500.00) running to the State of North Carolina, conditioned that any well opened by the drilling operator upon abandonment shall be plugged in accordance with the rules and regulations of said Department of Conservation and Development. (1945, c. 765, s. 2.)

§113-379. **Filing log of drilling and development of each well.**—Upon the completion or shutting down of any abandoned well, the drilling operator shall file with the Department of Conservation and Development or other State agency, or with any division thereof hereinafter created for the regulation of drilling for oil or natural gas, a complete log of the drilling and development of each well. (1945, c. 765, s. 3.)

§113-380. **Violation a misdemeanor.**—Any person, firm or officer of a corporation violating any of the provisions of §§ 113-378 or 113-379 shall upon conviction thereof be guilty of a misdemeanor and shall be fined not less than five hundred dollars ($500.00) nor more than two thousand dollars ($2,000.00) and may in the discretion of the court be imprisoned for not more than two years. (1945, c. 765, s. 4.)

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NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
HARGROVE BOWLES, JR., *Director*

DIVISION OF MINERAL RESOURCES
JASPER L. STUCKEY, *State Geologist*

Economic Paper 67

Mineral Industry of North Carolina From 1954 Through 1959

By

JASPER L. STUCKEY AND STEPHEN G. CONRAD

RALEIGH

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Members of the Board of Conservation and Development

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Letter of Transmittal

Raleigh, North Carolina
March 10, 1961

To His Excellency, HONORABLE TERRY SANFORD
Governor of North Carolina

SIR:

I have the honor to present herewith manuscript for publication as Economic Paper 67, "The Mineral Industry of North Carolina from 1954 through 1959".

North Carolina is rapidly becoming an important producer of minerals. This report contains a summary and review of the mineral industry of the State for the period 1954-1959 during which the tonnage and value of minerals produced were the greatest ever recorded during any six year period. Information is also included showing the importance of minerals to the manufacturing industry of the State. It is believed that this report contains information of value to mineral producers, manufacturers and others interested in the minerals found in North Carolina.

Respectfully submitted,

HARGROVE BOWLES, JR.
Director

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THE MINERAL INDUSTRY OF NORTH CAROLINA FROM 1954 THROUGH 1959

By

JASPER L. STUCKEY and STEPHEN G. CONRAD

ABSTRACT

ring the period 1954-1959, the mineral industry orth Carolina reached an all-time high in both ge and value. The average annual value of the 's mineral production was $40,346,000, and the ge annual tonnage was 21,168,548 tons. This sents an increase of 62.6 percent in value and percent in tonnage over the previous reported d of 1946-1953.

nmetallic minerals, copper, iron ore, lead and tungsten and by-product gold and silver com- d the mineral production of North Carolina g 1954-1959. Nonmetallic minerals are by far ost important mineral resources and accounted pproximately 90 percent of the State's total al production. In order of value, stone, sand gravel, mica, feldspar, copper, tungsten and are the principal minerals mined. In 1959, Carolina led all states in producing feldspar, and scrap mica, olivine and lithium minerals umene). It was third in the production of talc yrophyllite combined and was the only state cing millstones.

period was one of marked progress and ex- on throughout most segments of the industry. ction facilities were expanded and modernized ny companies and many new mining and ore- nent methods were employed. Two new brick and one sewer pipe went into production dur- e period. In 1954, the State became a producer pper for the first time since 1944 and in 1959 ction of iron ore was resumed for the first since 1936. Consolidations and mergers of ed stone producers were a highlight of 1959. ior Stone Company and Bryan Rock and Sand ny, consolidated and subsequently became a n of American-Marietta Company. Vulcan Ma- purchased a number of independent quarries. l of 33 or more pits and quarries were involved se mergers and acquisitions.

th Carolina is rapidly becoming an important acturer of stone, clay and glass products. It is estimated that there are more than 100 plants of all types engaged in manufacturing products from mineral raw materials in the State. Taking into consideration the value of all rocks and minerals mined and processed in the State, plus the value of stone and glass products manufactured in the State from both imported and native minerals, it is estimated that the average annual value of the mineral industry to the economy of North Carolina is in excess of $100,000,000.

INTRODUCTION

The potential mineral wealth of North Carolina is much greater than is generally recognized. More than 300 varieties of minerals and rocks have been identified in the State which is reported to be the greatest number found in any state. North Carolina contains deposits of metallic minerals, nonmetallic minerals and rocks, and mineral fuels, but is best known as a producer of nonmetallic minerals and rocks. During the period 1954-1959 metallic minerals and nonmetallic minerals and rocks were mined but no mineral fuels were produced.

In the order of value stone (granite, gneiss, slate, limestone and marble), sand and gravel, mica, feldspar, kaolin, clay and shale, and spodumene are the nonmetallic minerals and rocks most commonly produced. Copper, gold and silver, iron, titanium and tungsten minerals have been produced in recent years. In 1959, North Carolina led all States in the production of feldspar, primary kaolin, sheet and scrap mica, olivine and lithium minerals (spodumene). It was third in the output of talc and pyrophyllite combined and was the only State that produced millstones.

Information on the tonnage and value of minerals produced in North Carolina is collected in cooperation with the United States Bureau of Mines. It is the policy of that agency to collect and report the mine value of minerals without regard to any value that may be added by processing. A number of minerals such as clays and shales, feldspar, scrap mica, and talc and pyrophyllite are of little or no value in the raw state as they come from the mine and must be processed to some extent to be marketable. The body of this report deals with the values of minerals as they come from the mine. At the end of the report an attempt is made to show the value added by processing and to indicate the over-all value of the mineral industry to the State of North Carolina.

Acknowledgments

This report is a compilation of information found in many published and unpublished reports from which the writers have made free use with proper acknowledgment. Included, are reports of the United States Bureau of Mines, United States Geological Survey, North Carolina State College Minerals Research Laboratory, various articles in technical publications and from the files and published reports of the North Carolina Department of Conservation and Development. Statistics used in the preparation of the accompanying graphs and tables are from data collected by the U.S. Bureau of Mines in cooperation with the Division of Mineral Resources. Much of this information is published annually in the United States Bureau of Mines Mineral Yearbook.

Statistical Review

Table 1 summarizes the mineral production of North Carolina by items and years for the period 1954-1959. The mineral production of the State varied from $41,651,000 in 1954 to $40,789,423 in 1959 and averaged $40,346,000 for each year of the period, which was the greatest ever recorded for any six year period. The tonnage production ranged from 20,439,000 tons in 1954 to 24,388,000 tons in 1959 and averaged 21,168,548 tons per year, which was the greatest tonnage production ever recorded in any six year period. This indicates that the mineral industry of North Carolina is growing rather than showing an increase in value due to rising prices.

Table 1. Mineral Production in North Carolina, 1954-1959—Mine Value

	1954	1955	1956	1957	1958	19[illegible]
Abrasive stones (grinding pebbles, millstones, tube-mill liners)	$ 18,125	$ 12,104	$ 15,741	$ 12,750	$ 12,450	$ [illegible]00
Asbestos	(1)	(1)	(2)	(1)	(1)	[illegible]
Beryl (beryllium concentrates)	556	121	1,805	1,000	(1)	[illegible]
Clays and Shales[4]	2,519,721	1,792,081	2,026,709	2,054,000	1,520,007	1,7[illegible]54
Copper	106	112	850	(1)	(1)	[illegible]1)
Feldspar	2,220,707	2,184,793	3,191,559	2,728,000	2,519,713	2,9[illegible]52
Gem Stones	(2)	10	1,000	260	1,290	[illegible]00
Gold	7,490	6,650	30,870	48,000	31,000	[illegible]00
Kaolin	(4)	(4)	(4)	(4)	(4)	[illegible]
Lead	1,049	596	3,140	3,000	(2)	[illegible]
Lithium	(1)	(3)	(3)	(3)	(1)	[illegible]
Mica: scrap and flake	1,457,122	1,377,035	1,064,631	1,173,000	1,041,000	1,2[illegible]00
Mica: sheet	1,787,197	2,745,234	2,135,057	1,575,000	1,722,000	1,7[illegible]00
Olivine	(1)	(1)	(1)	(1)	(1)	[illegible]
Sand and Gravel	5,508,284	5,911,223	6,264,135	5,724,000	5,880,000	7,4[illegible]00
Silver	396	164	682	11,000	14,000	[illegible]00
Stone: granite, gneiss, slate and miscellaneous rocks[5]	13,009,251	13,497,220	13,842,963	15,296,326	15,712,761	16,8[illegible]00
Stone: limestone, marble and marl	2,616,080	3,035,690	3,105,766	3,950,458	3,419,329	3,4[illegible]00
Talc and Pyrophyllite	388,428	571,689	529,205	558,000	614,000	6[illegible]00
Zinc	(2)	(2)	(2)	(1)	(2)	[illegible]
Tungsten	(1)	(1)	(1)	(1)	(1)	[illegible]
Vermiculite	(1)	(1)	(2)	(2)	(2)	[illegible]
Undistributed[6]	12,116,387	10,074,829	8,657,880	4,529,466	7,403,949	4,6[illegible]17
Total	$41,651,000	$41,210,000	$40,870,150	$37,664,260	$39,891,409	$40,7[illegible]23

(1) Included in undisturbed
(2) No production reported
(3) Production figures not collected (data classified)
(4) Kaolin included in clays and shales
(5) Includes quartz, quartzite and ground sand stone
(6) Inclules asbestos, beryl except in 1956, copper except in 1954, 1955 and 1956 iron ore 1959, lithium, olivine, zinc 1957, tungsten, vermiculite 1954 and 1955

Growth is further emphasized by pointing out that, ; shown in Economic Paper 66, the value of miner- s produced in the period 1946-1953 varied from 4,947,000 in 1946 to $38,458,000 in 1953 and ave- ged $24,810,850 for each year of the period, while nnage production varied from 10,016,000 tons in 46 to 18,010,000 in 1953 and averaged 14,347,182 ns for each year of the period. This is an increase annual value of $15,535,150 and an increase in nnage of 6,821,366 tons in the period 1954-1959 er the period 1946-1953.

The relative value of minerals produced in North rolina during the period 1954-1959 is shown in Figure 1 which gives the average annual value for the various minerals produced during the period. Copper, lithium, tungsten, and miscellaneous minerals and rocks made important contributions and accounted for $6,904,871 or 18.8 percent of the total production. Nonmetallic minerals and rocks dominated production. Stone accounted for $17,965,836 or 44.5 percent of production; sand and gravel, $6,118,940 or 15.2 percent; mica, $3,174,046 or 7.9 percent; feldspar $2,629,870 or 6.5 percent; clay and shale $1,950,612 or 4.9 percent; while gold and silver accounted for $33,207 or 0.8 percent.

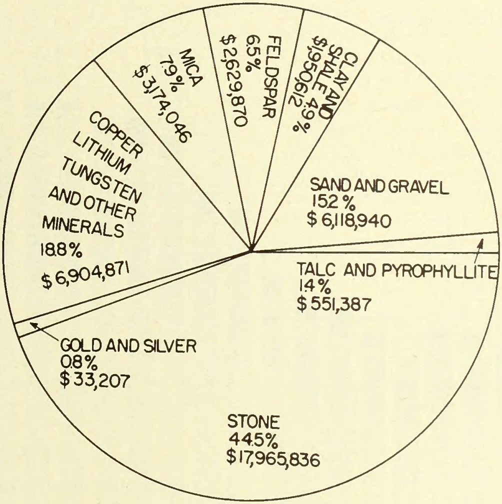

FIGURE 1. AVERAGE ANNUAL VALUE OF MINERAL PRODUCTION BY COMMODITY IN NORTH CAROLINA, FROM 1954 THROUGH 1959.

Figure 2 shows graphically the growth in value of the mineral production of North Carolina for the 20 year period 1939-1959. The average annual value of minerals produced in North Carolina during the decade 1940-1949 was $18,554,739, while during the decade 1950-1959 the average annual value wa $37,106,778. This is an increase of almost e ctl 100 percent in the decade 1950-1959 over the c ad 1940-1949.

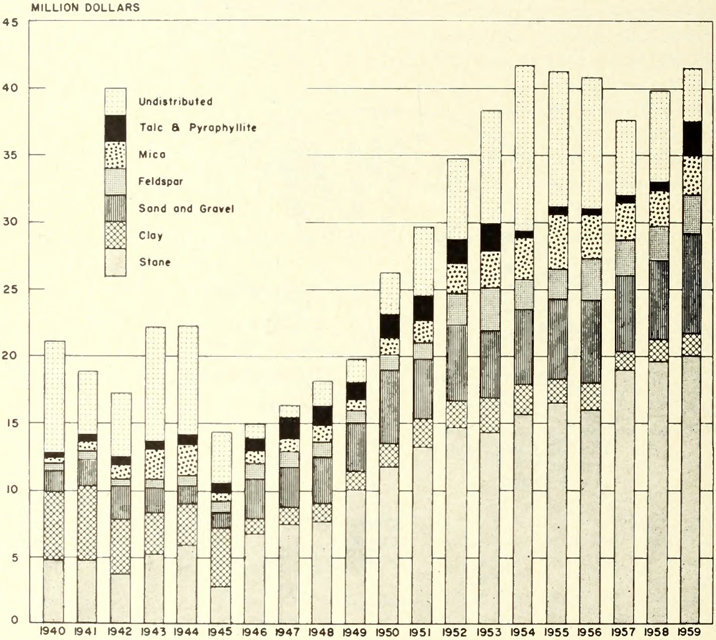

Figure 2.- Value of stone, clay, sand and gravel, feldspar, mica, talc and pyrophyllite, and total value of mineral production in North Carolina, 1940–1959. Undistributed values include abrasive stones, asbestos, copper, gold, lead, silver, olivine, tungsten concentrates, etc.

Table 2 shows the annual value of minerals pro-
ιced in North Carolina from 1900 through 1959.

BLE 2. Annual Value of minerals produced in North Carolina 1900-1959

ar	Total Value	Year	Total Value
00	$ 1,604,078	1930	$10,086,459
01	1,779,109	1931	7,581,384
02	2,003,077	1932	3,794,999
03	1,902,485	1933	5,243,158
04	1,985,675	1934	6,754,471
05	2,439,381	1935	7,502,567
06	3,007,601	1936	9,955,519
07	3,173,722	1937	13,049,056
08	2,308,116	1938	14,959,228
09	2,873,826	1939	18,533,720
10	2,848,446	1940	21,112,732
11	2,933,878	1941	18,915,461
12	3,514,892	1942	17,372,690
13	3,879,340	1943	22,172,000
14	3,692,461	1944	22,199,000
15	3,584,725	1945	14,457,000
6	4,746,674	1946	14,947,238
7	5,411,452	1947	16,385,272
8	5,192,047	1948	18,231,000
9	6,404,679	1949	19,755,000
0	8,117,916	1950	26,343,000
1	5,676,301	1951	29,646,000
2	7,483,305	1952	34,730,943
3	11,050,257	1953	38,458,350
4	10,163,437	1954	41,651,000
5	10,699,422	1955	41,219,000
6	11,274,224	1956	40,870,150
7	12,566,822	1957	37,664,260
8	12,355,934	1958	39,891,409
9	14,668,817	1959	40,789,423

Mineral Resources

s indicated above, North Carolina contains ap-
ximately 300 varieties of minerals and rocks.
ne of these are not abundant and are of interest
efly to collectors. Others are widespread but are
concentrated in sufficient amounts to be of eco-
nic importance. Approximately seventy varieties
minerals and rocks that have commercial value
known to occur in the State and some thirty to
y of these have been produced during the present
ury. The minerals of commercial value that have
n produced, or explored for, during the period
4-1959 are described below under three classes,
ely, metallic minerals, nonmetallic minerals and
s, and mineral fuels. It is not always possible to
v a perfect line between metallic and nonmetallic minerals, but this classification has much to recommend it and is used here.

Metallic Minerals

North Carolina is not and never has been an important producer of metallic minerals. It does, however, contain varying amounts of several metals some of which have been successfully produced. During the period of this report there was some interest or activity in the following metals: aluminum, beryllium, copper, gold and silver, iron, lead and zinc, titanium, tungsten and uranium.

Aluminum

Commercial deposits of aluminum ore are not known to occur in North Carolina. However, Aluminum Company of America operated at Badin, North Carolina an aluminum smelter during the period 1954-1959. According to the 1959 Minerals Yearbook of the U.S. Bureau of Mines this smelter has a primary-aluminum productive capacity of 47,150 short tons per year. It is located at Badin because of available electric power and operates on imported ore.

In 1957 Aluminum Company of America and Kaiser Aluminum Company acquired leases on large tracts of land in the Spartanburg-Rutherfordton area of South and North Carolina and prospected for aluminum-bearing ore but no production was made.

Beryllium

As shown in Table 1, above small amounts of beryllium concentrates (beryl) were produced each year of the period covered by this report. Small amounts of beryl are associated with pegmatites in the western part of the state and the small production reported came largely as a byproduct of feldspar and mica mining. According to W. R. Griffitts, U.S. Geological Survey Circular 309, "Beryllium Resources of the Tin-Spodumene Belt, North Carolina", (1954) that belt contains 823,000 tons of beryl, equivalent to 122,800 tons of BeO. These figures are based on a BeO content of 0.05 percent in the pegmatites of the Tin-Spodumene Belt. If a process for concentrating the beryl present in these pegmatites can be developed, North Carolina should become an important producer of beryllium ore. The U.S. Bureau of Mines has been working on the problem for some time but no results have been reported.

Copper

In 1954, North Carolina became a producer of copper for the first time since 1944. The small production in 1954, 1955 and 1956 came from H and H mine which is located near Glenview in Halifax County about eight miles southwest of Enfield. H and H Mining Company continued to produce copper at its mine near Glenview during 1957 but reported no production in 1958 and 1959.

During the period of this report several companies including Tennessee Copper Company, Roland F. Beers, Inc., American Smelting and Refining Company and Nipissing Mines, Limited, examined several prospects in the State. In 1953 and 1954, Nipissing Mines, Limited, carried out an extensive core drilling program at the old Ore Knob mine in Ashe County. In 1954, title was taken to the property and work was continued under the name Appalachian Sulfides, Inc. In 1955, American Smelting and Refining Company explored the property of H and H mines in Halifax County for copper, gold, lead and zinc, but made no production.

Exploratory work at Ore Knob included an electromagnetic survey and the drilling of 38 exploratory holes totaling 27,752 feet. The ore body was intersected in 15 holes with the deepest ore indicated at 1,150 feet. Based on the results of this drilling program, an ore body averaging 14.4 feet in width, 3,500 feet in length and ranging from 200 to 550 feet in vertical height was blocked out. The initial ore reserves were indicated to be 1,330,300 tons of 3.0 percent copper and 14 percent sulphur.

The Ore Knob vein is a steeply dipping (70°) tabular body that strikes N 64°E and has a rake of 20° to the southwest. It is believed to be a mineralized fault and consists of brecciated fragments of wall rock surrounded and replaced by sulphides. Two main types of mineralization have been recognized: massive pyrrhotite-pyrite-chalcopyrite that contains sealed fragments of wall rock; and disseminated to massive granular pyrite with a little chalcopyrite and pyrrhotite. The country rock is a "Carolina" type quartz-mica gneiss which makes sharp and well defined contacts with the ore body.

A vertical, three-compartment shaft was started in 1955. It was sunk in the foot wall of the ore body to a depth of 1,039 feet and completed in 1956. Initial cross-cuts to intersect the ore were started on the 560, 700 and 840 foot levels.

A crushing and milling plant to concentrate the ore was completed in February 1957. It consisted of mining, crushing and grinding equipment to process the ore for flotation and two twin 350 ton per day flotation circuits. One circuit was completed and put into operation in February 1957 before work was started on the second. The second circuit, which doubled the capacity of the plant, was completed a put into operation in March 1959. Concentrates trucked to nearby West Jefferson and shipped rail to a custom smelter in New Jersey. In 1958 shaft was deepened and further drilling was d under a DMEA contract.

In addition to examining other properties in we ern North Carolina, Nipissing Mines, Limited, c ried out, during parts of 1953 and 1954, an explo tion program for copper ore in the Virgilina dist of Person and Granville Counties. This progr which included geochemical studies and explorat drilling, failed to reveal copper ore of the gra being sought and no mining was done in that ar

After examining several properties in the Sta Roland F. Beers, Inc., explored the Denton prope in Davidson County in 1958 under a DMEA contr for copper, lead and zinc. Mining was not started

Gold and Silver

Gold and silver were produced in small amou each year of the period 1954-1959 as shown in Ta 1, above. During the years 1954, 1955, 1956 a 1957, H and H Mining Company, recovered g from the H and H mine located near Glenview Halifax County about eight miles southwest Enfield. During 1957, 1958 and 1959, Appalach Sulphides, Inc., produced gold and silver as a l product from the Ore Knob copper mine.

During the period of this report there was inter in gold and some prospecting was carried out several old mines. The only work of this type th was at all successful was carried out at what is n known as the Star mine about four miles southw of Star in Montgomery County. Mr. H. A. Knig Sr., of High Point did open cut work at this m in 1954 and 1955. In 1955 he activated an old cyan plant at the Candor (old Colossus or Howie mi near Waxhaw, Union County and shipped some to this plant for processing. It is reported th $20,000 worth of gold was recovered, but the ve ure was not profitable and operations ceased bef the end of 1955.

About 1958 or 1959, exploration was renewed a several drill holes were put down on the proper and other prospecting was done. Later, a two co partment shaft was started into the ore body at angle of 45°. The core drilling and the shaft, p several cross cuts, have revealed an ore body a proximately 100 feet wide and of unknown leng and depth that appears to contain gold ore of co mercial grade. A new 100 ton per day capac cyanide plant has been constructed at the Cand ne near Waxhaw, Union County for processing the e. All indications, late in 1960, were that this ould be a successful gold mining venture. The ne is known as the Star mine and the operations e being conducted under the name of Union Refin- and Mining Company. The president of the com- ny is H. A. Knight, Sr., Box 1247, High Point, rth Carolina.

Iron

North Carolina became a producer of iron ore in 59 for the first time since 1936. Cranberry Mag- ite Corporation reopened the old Cranberry mine Avery County, which had been idle since 1929 d shipped a small amount of magnetite to Bir- ngham, Alabama.

The Cranberry mine was operated intermittently m about 1881 to 1929 and produced about 1,500,- tons of ore. In 1943-1944, the U.S. Bureau of nes examined the property, did core drilling and ned 1,400 tons of ore. This ore was concentrated a pilot plant at the mine to 70 percent iron con- trate and shipped to Salisbury. In a plant at isbury a sponge iron containing 97 percent iron s produced.

An analysis of the drilling done by the U. S. Bureau Mines, indicates at least as much ore in the mine has been removed. Appalachian Exploration Com- y secured a lease on the property and carried out loration work in 1957-1958. In 1959, Cranberry gnetite Corporation secured a 20-year lease on property and began small scale mining. An- nced plans call for the production of 100 tons per of fine-ground (70 mesh) concentrate suitable media in coal washing plants and the construction an electric furnace on the property to produce h-grade metallic iron.

Lead and Zinc

mall amounts of lead were produced in 1954, 1955, 96 and 1957. Zinc was produced only in 1957. The d and zinc produced during these years came from h H and H mine located near Glenview in Halifax nty about eight miles southwest of Enfield.

uring the period of this report, several companies uding New Jersey Zinc Company, Roland F. rs, Inc., and Tennessee Copper Company, carried examinations and explorations of some old lead, and copper deposits. In 1955-1956, New Jersey Company, examined several prospects but did detailed exploration. Roland F. Beers, Inc., ex- ned a number of sulphide deposits and in 1958 explored the Denton property in Davidson County for copper, lead, zinc, under a DMEA contract. Tennessee Copper Company, examined several old prospects and in 1958-1959 carried out an extensive drilling program at the Silver Hill mine in Davidson County which revealed the presence of important amounts of lead and zinc ore. In the fall of 1959, work was started on cleaning and deepening an old shaft to reach the ore discovered by drilling. Considerable progress had been made on this work by the end of the year.

Titanium

No titanium minerals were produced in North Carolina during the period of this report. However, titanium minerals of some interest are known to occur in two areas of the State. Ilmenite occurs in varying amounts in the sands and sounds of the eastern part of the Coastal Plain. Rutile occurs along Shooting Creek and adjacent areas in Clay County.

Between January 1956 and January 1959, W. H. Rodenbeck and Associate, and Graham D. Monroe, held leases on parts of the sounds in the eastern part of the Coastal Plain to explore for titanium minerals (ilmenite). Some exploration was carried out but no production was reported. In 1955, American Smelting and Refining Company, leased 2200 acres along Shooting Creek in Clay County and carried out exploration work on the rutile deposits found there. Considerable rutile was found in the area, but the tonnage was too small for American Smelting and Refining Company's needs and the project was discontinued.

Tungsten

Tungsten minerals are known to occur in two localities in North Carolina. One of these localities is in Cabarrus County and the other is in the northwestern part of Vance County.

Small amounts of scheelite have been found at several old gold and copper mines in Cabarrus County. Among these are the California, Phoenix, Furniss, Flowe, Cline and Crosby. In 1946 and 1948 to 1950, the U.S. Bureau of Mines did drilling at the Cline mine and at the Furniss mine. During these years no production was made. In 1954 new interest was developed in the area and in 1955 and 1956, DMEA aided Carolina Tungsten Mining Company in further exploration. The Phoenix mine was unwatered and examined, and further examinations were made at the Cline and Furniss mines. Commercial deposits of tungsten minerals were not found and mining attempts were discontinued.

Near Townsville, in the northwestern part of Vance County, Tungsten Mining Corporation produced tungsten ore from the Hamme mine during the period 1954 through June 30, 1958 when the mine and mill were closed down due to market conditions. The mine and mill were reactivated April 1, 1960.

Thorium and Uranium Minerals

In North Carolina, the principal occurrences of monazite, the chief thorium-bearing mineral, are in Cleveland, Burke and Rutherford Counties. Smaller amounts occur in Madison, Surry, Wake and other counties. For many years North Carolina was an important producer of monazite but during the period of this report there was little interest in monazite and no production was reported.

Several uranium-bearing minerals are known to occur in North Carolina. These minerals are found principally as minor constituents of pegmatite dikes. They appear to be most abundant in the Spruce Pine district and adjacent areas where small amounts have been recovered as by-products of feldspar and mica mining. During the period of this report, especially in 1954 and 1955 there was renewed interest in uranium-bearing minerals in the State and several individuals, groups and mining companies, including New Jersey Zinc Company and Putnam Mineral Exploration Company, examined prospects and carried out some exploration in Avery, Burke and Caldwell Counties. No commercial deposits were found and no production was reported.

NONMETALLIC MINERALS

Abrasive Stones

Natural abrasives found in North Carolina include corundum, emery, garnet, quartz, quartzite and granitic rocks. However, in recent years, manufactured abrasives have to a large degree replaced natural abrasives, and the only native material used during the past 6 years for abrasive stone was granite from Rowan County.

The Gardner Granite Works and the Harris Granite Quarries, Inc., produced grinding pebbles, millstones and tube-mill liners. Because of the limited number of producers, individual production figures of the various abrasive materials cannot be revealed. However, the average annual value of all abrasive materials produced from 1954 through 1959 was approximately $16,855.00.

Asbestos

Asbestos is associated with basic igneous rocks, commonly referred to as peridotites, at a number of localities in the western Piedmont and Mountain regions of North Carolina. Anthophyllite, the amphibole variety, is the most common, but chrysotile is known to occur at several places. In general, the individual deposits are small, but where several deposits are located in the same vicinity the asbestos has been mined economically.

Although the annual production of asbestos from North Carolina has been comparatively small and inconsistent, the State has been a producer for more than fifty years. Over the years, considerable tonnages have been mined from Macon, Jackson, Transylvania, Avery, Mitchell and Yancey Counties. During the period covered by this report, amphibole asbestos production is recorded for 1954, 1955, 1957, 1958 and 1959. The Powhatan Mining Company, Woodlawn, Baltimore, Maryland, and the Mining and Milling Corporation of America, operated mines in Transylvania and Yancey Counties respectively. During 1954 the Mining and Milling Corporation ceased operations at its Blue Rock mine and the Powhatan Mining Company has accounted for all of the asbestos production since 1955.

Cement

Although, North Carolina has never been a producer of portland cement, several significant things took place during the period covered by this report which may lead to the culmination of many years of diverse effort to establish a cement plant in the State.

In January 1950, a project to study the available raw materials necessary for producing portland cement, was started under the joint sponsorship of the Department of Conservation and Development, the Highway and Public Works Commission and the Department of Agriculture. This survey was conducted principally in the Coastal Plain region and resulted in the discovery of a large tonnage of high-grade marl and limestone in the vicinity of Maple Hill, Pender County.

Following investigations by the State, the Volunteer Portland Cement Company, Knoxville, Tennessee, acquired considerable acreage in the area and carried out an extensive exploration program. This program established the fact that enough high-grade marl and limestone are present in the Maple Hill deposit to support a modern cement plant. The Volunteer Company then proceeded to develop plans for he construction of a plant having an annual capacity of 1 million barrells. However, before these plans were completed, the Volunteer Portland Cement Company became a wholly owned subsidiary of deal Cement Company of Denver, Colorado. This merger took place in late 1959.

In June of 1960, the Ideal Cement Company announced plans to construct a cement plant near Wilmington. The plant will involve a capital outlay of about $15 million and have a capacity of 1.5 million barrels per year. In addition to the manufacturing facilities at Wilmington, a distribution terminal is planned at Fayetteville. When the plant will begin production is uncertain at this time, but a date of about 1962 or 1963 is expected.

In addition to the activity of the Ideal Cement Company, several other cement companies spent onsiderable time and effort investigating other marl and limestone deposits in the Coastal Plain, s well as crystalline limestone deposits in the Piedmont and Mountain regions. Exploratory drilling rograms were conducted in Henderson, Buncombe, McDowell, Yadkin, Stokes and Pitt Counties. Howver, no important discoveries of limestone or marl uitable for portland cement have been announced s a result of this drilling.

Clay, Shale and Kaolin

North Carolina is a leading producer of clay, the rinciple types being: (1) common clays and shales uitable for the manufacture of brick and other ructural clay products, including lightweight agregate; and (2) minerals of the kaolin group which nstitute high-grade china clays. Common clays nd shales occur throughout the State and practilly every county contains deposits suitable for the manufacture of common brick. However, commercial aolin deposits are restricted largely to the area west f the Blue Ridge Mountains.

The period covered by this report was one of marked progress in the heavy clay products industry n North Carolina. Many of the companies enlarged nd modernized their plants. In 1955, Pomona Terra otta Company completed a new sewer pipe plant t Gulf, Chatham County and Etowah Brick Comany, Inc., Henderson County, built a new brick lant.

In 1956, clay production in North Carolina reached n all-time high of 2,641,387 tons. The general econmic decline, which started in 1957, was reflected n the heavy clay products industry by a 9 percent decline in tonnage and value of clay used during 1957, and an additional 14 percent decline in tonnage in 1958. However, in 1959, clay production increased considerably and was only 117,756 tons below the all-time high reached in 1956.

In 1959, improvement and expansions at brick plants included: Bennett Brick and Tile, Inc., at Kings Mountain; Pine Hall Brick and Pipe Company, at Pine Hall; and Borden Brick and Tile Company at Durham. In addition, Triangle Brick Company began construction, late in the year, on a new brick plant in Wake County near the Research Triangle. The plant, which went into production in June 1960, is modern throughout with a 540 foot tunnel kiln, the longest and largest in the State. Local clays and shales of Triassic age, which are abundant in the area, will serve as the chief raw materials. The company will specialize in the manufacture of distinctive face and building brick.

Lightweight aggregate was produced by Carolina Tuff-Lite Company near Salisbury, Rowan County and by Southern Lightweight Aggregate Corporation at Aquadale, Stanly County, during the period of this report. In 1958, Southern Lightweight Aggregate Corporation, built a two-kiln plant at Leaksville Junction, Virginia and began the manufacture of lightweight aggregate from clay produced in North Carolina. In 1959, Carolina Solite Corporation, enlarged its Aquadale plant by the addition of a new kiln.

Kaolin was produced during the period of this report by Harris Clay Company, Spruce Pine, North Carolina. The bulk of the production came from Avery County, but a small production was reported from Mitchell County in 1954, 1955 and 1958. Roy Grindstaff produced kaolin in 1954 and 1958.

TABLE 3. Clay Sold or Used in North Carolina, 1954-1959

Year	Short tons	Value	Value/ton
1954	1,872,541	$2,519,721	$1.35
1955	2,375,494	1,792,081	.75
1956	2,663,000	2,027,000	.76
1957	2,729,180	2,053,526	.75
1958	2,047,000	1,187,000	.58
1959	2,524,000	1,522,000	.60

Principal Producers of Clay in North Carolina, 1959 *

Company	Address	County
Bennett Brick and Tile Company	Kings Mountain	Cleveland
Borden Brick and Tile Company	Durham	Durham, Lee
Boren Clay Products	Pleasant Garden	Guilford, Chatham
Carolina Tuff-Lite Corporation	Salisbury	Rowan
Chatham Brick and Tile Company	Gulf	Chatham
Cherokee Brick Company of N. C.	Raleigh	Chatham
Crumpler Brick Company, Inc.	Roseboro	Sampson
Cunningham Brick Company	Thomasville	Davidson
Fletcher Brick Company, Inc.	Fletcher	Henderson
Hanford Brick Company, Inc.	Burlington	Alamance, Lee
Harris Clay Company	Spruce Pine	Mitchell

Ideal Brick Company	Fayetteville	Cumberland
Isenhour Brick and Tile Company	Salisbury	Rowan
Kendrick Brick and Tile Company	Monroe	Union
Mt. Gilead Brick Company	Mt. Gilead	Montgomery
Nash Brick Company, Inc.	Rocky Mount	Halifax
Norwood Brick Company	Lillington	Harnett
Patterson Brick Company	Roseboro	Sampson
Pine Hall Brick and Tile Company	Winston-Salem	Stokes
Pomona Terra Cotta Company	Pomona	Chatham
Roanoke-Webster Brick Company	Draper	Rockingham
Sampson Brick Company, Inc.	Roseboro	Sampson
Sanford Brick and Tile Company	Colon	Lee
Southern Lightweight Aggregate Corp.	Aquadale	Stanly
Stanly Shale Products, Inc.	Norwood	Stanly
Statesville Brick Company	Statesville	Catawba
Yadkin Brick Yards, Inc.	New London	Stanly

*Includes kaolin.

Feldspar

North Carolina continued as the leading producer in the United States of both crude and ground feldspar. It accounted for approximately 45 percent of the crude and ground feldspar production during the period under consideration.

During the period 1954-1959, average annual production of crude feldspar was 246,551 long tons valued at $2,629,913. This represents a 17.9 percent increase in tonnage and a 72.2 percent increase in value over the period 1946-1953.

In 1959, 14 producers mined crude feldspar from Avery, Mitchell, Swain and Yancey Counties. Mitchell County ranked first in production and the leading producers were International Minerals and Chemical Corporation (Hawkins and Kona mines); the Feldspar Corporation (Poteat, Wiseman, Sullins, Dogwood Flats and Chestnut Flats mines) and Lawson-United Feldspar and Minerals Company (Minpro mine).

Crude feldspar is obtained from pegmatites and alaskite. Block feldspar from pegmatites is trucked to grinding plants where it is crushed and ground to the desired size. Alaskite is trucked to grinding and flotation plants where it is ground to approximately 20-mesh and the feldspar from the alaskite is separated from the associated quartz and mica by froth flotation. The quartz and mica are recovered by the flotation process as by-products. Part of the feldspar is ground finer (down to 200-mesh) and is sometimes blended to meet special market requirements.

For the years 1954-1959, the average annual production of ground feldspar sold by merchant mills in North Carolina was 245,303 short tons, valued at $3,466,035. This represents an increase of 12.5 percent in tonnage and 25.2 percent in value over the period 1946-1953.

Producers of Ground Feldspar in North Carolina from 1954 through 1959

Company	Plant Locati
Feldspar Milling Company (1954 only)	Bowditch
The Feldspar Corporation	Burnsville, Spruce Pi
Consolidated Feldspar Division of International Minerals & Chemical Corp.	Kona, Spruce Pine
Lawson- United Feldspar and Mineral Company (1957, 1958, 1959)	Minpro

The ceramic industries consume practically all the feldspar concentrate produced in North Carolin During the period 1954-1959 approximately 65 pe cent of the total feldspar production went to th glass industry, 30 percent to pottery and 5 percent enamel. A small amount was used in other ceram processes and in soaps and abrasives.

Table 4. Crude Feldspar Produced in North Carolina and t United States from 1954 through 1959

	North Carolina		United States	
Year	Long Tons	Value	Long Tons	Value
1949-1953 (average)	205,742	$1,803,484	459,667	$3,466,0
1954	230,744	2,220,707	526,590	4,517,0
1955	242,724	2,184,793	550,861	4,528,0
1956	255,637	3,191,559	560,074	5,820,0
1957	233,439	2,728,153	498,057	4,935,0
1958	224,647	2,519,713	469,738	4,278,0
1959	292,114	2,934,552	Figures-not availa	

Table 5. Ground Feldspar Sold by Merchant Mills in Nor Carolina and in the United States from 1954 through 19

	North Carolina		United States	
Year	Short Tons	Value	Short Tons	Value
1949-1953 (average)	220,136	$3,044,459	500,769	$6,853,0
1954	210,804	3,123,096	568,480	7,684,0
1955	249,855	3,850,265	596,158	8,584,0
1956	261,430	4,044,653	608,661	8,957,0
1957	237,655	3,406,055	503,170	7,062,0
1958	232,625	3,120,619	469,602	6,540,0
1959	279,448	3,251,522	Figures not availa	

Producers of Crude Feldspar in 1959

Producer	Address	County
Banner Mining Company	Spruce Pine	Mitchell
Bobby Winters	Spruce Pine	Mitchell
Buchanan and Buchanan	Spruce Pine	Mitchell
Charlie Silvers	Spruce Pine	Avery
Cox and Thomas	Spruce Pine	Mitchell
International Minerals and Chemical Company	Skokie, Ill.	Mitchell
Laurence Buchanan	Spruce Pine	Mitchell
Lawson United Feldspar and Minerals Company	Spruce Pine	Mitchell
Lindsay Hallifield	Spruce Pine	Mitchell
Roy Grindstaff	Bakersville	Mitchell
Roy Huskins	Spruce Pine	Mitchell
Sinkhole Mining Company	Bakersville	Mitchell
The Feldspar Corporation	Spruce Pine	Mitchell, Av Swain, Yan
Winters and Burnett	Spruce Pine	Mitchell

Gem Stones and Gem Materials

During the period covered by this report a wide riety of gem stones and gem materials were col- cted in 19 or more counties in North Carolina. mong the minerals reported were: amethyst, beryl, rundum, emerald, garnet, hiddenite, kyanite, opal, by, sapphire, quartz and miscellaneous rock and ineral specimens. The gem material reported was lued at a total of $12,000. However, this total presents only a small part of the actual value of m material found in the State during the past six ars, because the majority of the material is found individual collectors and is not reported.

There have not been any attempts at systematic ining of gem stones in the State for a good many ars. However, an enterprize that has developed the past few years from the increased interest mineral collecting, is the opening up to the public l mine dumps and workings that were worked for m stones in the past. Individuals are allowed to llect on the property for a daily, or hourly, fee d may keep any gem material found. There are veral of these operations now open in the State, and ey have proved to be very popular. The best known these are along Cowee Creek in Macon County ere some outstanding rubies and sapphires have en found. Others are at Crabtree Mountain, Mitch- County, and Hiddenite, Alexander County.

North Carolina Dealers in Gem Materials and Mineral Specimens

Oscar Randolph	Box 718, Morganton, N. C.
yd A. Allison	1811 Cheek Rd., Durham, N. C.
d O. Scroggs	Brasstown, N. C.
ten B. Green	Spruce Pine, N. C.
oy Buchanan	Hawk, N. C.
vey Moose	Stoney Point, N. C.
yd Wilson	Micaville, N. C.
t Shuford Mineral Shop	Arden, N. C.

Graphite

raphite, also known as black lead and plumbago, one of the varieties of elemental carbon. It is a y soft, black, greasy feeling mineral which occurs st commonly in North Carolina as disseminated kes in gneisses and schists or as scaley or compact thy masses. Graphite is used in making crucibles, ndary facings, lubricants, pencils, crayons, paint, ve polish, commutator brushes and for many other s.

raphite is most commonly associated with gneis- schists and metamorphosed limestones, but also rs in pegmatites and other intrusive formations. ne of the better known occurrences in North Carolina are found in Alexander, Catawba, Cleveland, Macon, McDowell, Rutherford, Wake and Yancey Counties. There was some interest in graphite in North Carolina and several inquiries were made about graphite deposits in the State during the period covered by this report, but no exploration was carried out and no production of natural graphite was reported. However, Great Lakes Carbon Company produced synthetic graphite from imported materials at Morganton during the period of this report.

Lithium

The lithium industry has experienced tremendous growth during the past ten years and North Carolina has become the principle domestic producer of lithium minerals. An important factor in this rapid growth is the large volume of high-grade ore that has been discovered in the Kings Mountain district of Cleveland, Gaston and Lincoln Counties, North Carolina.

In 1955, Norton and Schlegel, U.S. Geological Survey Bulletin 1027-G, "Lithium Resources of North America", pointed out that the United States contained an estimated and inferred reserve of 138,800,000 units of LiO_2 of which 128,000,000 were in the Kings Mountain district. In 1956, Broadhurst, N. C. Department of Conservation and Development, Information Circular 15, "Lithium Resources of North Carolina", estimated that lithium ore in the Kings Mountain district which appeared favorable for mining, amounted to 41,500,000 tons with a lithium content of 1.25+ percent or approximately 55,030,000 units of LiO_2.

In 1960, Kesler, American Institute of Mining, Metallurgical and Petroleum Engineers, Industrial Minerals and Rocks, Chapter 24, "Lithium Raw Materials," stated, "by June 30, 1959, the crude ore reserves of Foote Mineral Company, amounted to 20,746,297 tons measured (1.53 pct Li_2O) and 15,769,075 tons indicated, based on the completed second stage of drilling on a tract 6,000 feet long. Lithium Corporation of America has a computed reserve of 9,683,000 tons (1.3 pct Li_2O) as a result of drilling. Indicated reserves on other properties total at least 15,000,000 tons averaging about 1.35 pct Li_2O. These reserves apply to some of the better properties, but only to limited depth and to only a small proportion of the district. Consequently, the ultimate reserves are probably larger than those given in all earlier estimates which were based largely on inference". These reserves constitute the worlds largest proved reserves of lithium ore and assure North Carolina a prominent place in the lithium industry for many years.

During the period 1954-1959, two companies mined or processed lithium minerals in the Kings Mountain district. Foote Mineral Company mined and processed spodumene at its Kings Mountain operation, and Lithium Corporation of America processed foreign ore at its Bessemer City plant. In August, 1959, Lithium Corporation of America announced plans to move its entire laboratory and manufacturing operations to Bessemer City from Minneapolis. Upon completion of this consolidation, the Bessemer City plant will be the only one in the United States processing lithium from ore to finished products. In addition to lithium hydroxide, which has been produced for the Atomic Energy Commission on a contract basis, the plant will produce other lithium products such as lithium bromide for use in air conditioners; butyl lithium for use in pharmaceuticals and synthetic rubber and lithium metal for use in alloys. Later, in November 1959, Lithium Corporation reopened its North Carolina mine upon cancellation and settlement of its contract to purchase ore from Quebec Lithium Corporation.

In addition to the activity of the Foote Mineral Company and Lithium Corporation of America, Texas Gulf Sulphur Company, took an option on lithium properties near Lincolnton, North Carolina, held by Basic Atomics, Inc. They planned to undertake engineering and economic studies relative to mining and treating the ore by a new process, the patent rights of which are held by Basic Atomics, Inc.

Since 1954, lithium production figures have been restricted because of its role in the United States atomic energy program. However, as can be seen from the accompanying table, production of lithium minerals has greatly accelerated since 1949. Although no figures are available a production of about 50,000 tons was anticipated by 1955. Production capacity in North Carolina alone would indicate the 1955 figure is conservative.

Table 6. Production of Lithium Minerals in the United States 1949-1954

Year	Ore (Short tons)	Value	Li_2O (Short tons)
1949	4,838	$ 345,970	475
1950	9,306	579,922	747
1951	12,897	896,000	956
1952	15,611	1,052,000	1,088
1953	27,240	2,134,000	1,767
1954	37,830	3,126,000	2,459

Mica

Although production and value fluxuated cor l- erably from year to year, North Carolina contir d as the leading producer of domestic mica during e period 1954-1959. In 1958, for instance, North C o- lina produced 79 percent of the total output of o- mestic sheet mica and over half the tonnage of domestic scrap mica.

Sheet Mica—In 1952 the federal government e- gan a program of purchasing domestically prodi d block, film and handcobbed muscovite mica at al e market prices for its stockpile of strategic def se minerals. This program is due to expire on June 0, 1962, or when the original quota of 25,000 short ns of hand cobbed mica, or its equivalent, is reac d. On September 30, 1959, the equivalent of 18 0 tons had been purchased (U.S. Bureau of M s Bulletin 585, p. 531).

This program greatly stimulated sheet mica n- ing in North Carolina after it had nearly ce d during the change over from a subsidized econ y of World War II to a peace time economy, in w h domestic mica had to compete with imported n a. In 1947, production of North Carolina sheet n a was the lowest recorded since 1933. However, s e 1947, the sheet mica industry in North Carolina s continued to expand and in 1956 a post war re d production of 770,903 pounds, valued at $2,135 7 was reached. During the period 1954-1959, the a - age annual production of sheet mica from N h Carolina was 568,083 pounds, valued at $1,953, 3. This represents an increase of 27 percent in pro - tion and 500 percent in value over the period 1 - 1953.

The major producing areas of sheet mica in N h Carolina are the Spruce Pine district, which incl s Avery, Mitchell and Yancey Counties; the Franl - Sylva district in Haywood, Jackson and Macon C - ties; and the Shelby district of Cleveland, Lin n and Gaston Counties. Sheet mica has also l n mined from many other counties in the Piedn t and Mountain regions of the State. During e period covered by this report, sheet mica was - ported mined from as many as 542 indivi l mines in 26 different counties. Mitchell Count , by far, the leading producer of sheet m i, followed by Yancey, Avery, Cleveland and - con Counties. In 1958, these five counties - counted for 98 percent of the tonnage and 92 per t of the value of all sheet mica produced in the St .

ble 7. **Recorded Production of Sheet Mica in North Carolina, 1954-1959**

ar	Pounds	Value	Average Value Per Pound
54	479,221	$1,787,197	$3.75
55	553,444	2,745,234	4.96
56	770,903	2,135,057	2.77
57	577,607	1,575,099	2.73
58	521,701	1,721,949	3.30
59	505,623	1,755,314	3.47

In 1959, sheet mica was produced from nineteen
unties by over 200 different producers. As a result,
attempt is made to give in this report a complete
t of sheet mica producers in the State.

Sheet mica is an important dielectric and insulat-
g material in the electronic and electrical indus-
es. That which does not go into the government's
ategic minerals stockpile, is sold to fabricating
nts, which stamp or punch the mica into shapes
d sizes required by the consumers. Most of the
ca fabricating plants are located in the electrical
ducts manufacturing centers in the eastern half
the country.

Mica Fabricators in North Carolina, 1959

npany	*Address*
penter and Phillips	Spruce Pine, N. C.
num Manufacturing Company	Asheville, N. C.
uce Pine Mica Company	Spruce Pine, N. C.
Heel Mica Company	Plumtree, N. C.

Scrap and Ground Mica—All mica which because
size, color or quality, does not meet the specifica-
ns for sheet mica, but which can be processed for
ustrial use as ground mica, is termed scrap mica.
North Carolina, the main sources of scrap mica
as waste from sheet mica mining, trimming and
ricating; as a byproduct from kaolin washing and
lspar and spodumene flotation; and that mined
ectly from scrap mica deposits. Approximately
percent of that produced in North Carolina is
ived from scrap mica deposits, which are large,
ply weathered or well kaolinized alaskite and
matite bodies that contain a high percentage of
mica.

cipal Producers of Scrap Mica in North Carolina, 1959

lucer	County
ris Clay Company	Avery
gs Mountain Mica Company, Inc.	Cleveland
e Mineral Company	Cleveland
strial Mica, Inc.	Mitchell
Veld Mica Corporation	Mitchell
rnational Minerals & Chemical Corporation	Mitchell
Feldspar Corporation	Mitchell
son United Feldspar and Mining Company	Mitchell
Southern Mica Company of North Carolina	Mitchell
Hassett Mining Company	Yancey
Deneen Mica Company	Yancey

Mitchell County is the leading producer of scrap mica, but Avery, Cleveland and Yancey Counties, also produce large tonnages. During the period 1954-1959, the average annual production of scrap mica was 53,524 tons, valued at $1,220,793, averaging $22.81 per ton.

Table 8. **Recorded Production of Scrap Mica in North Carolina, 1954-1959**

Year	Short Tons	Value
1954	61,049	$1,457,122
1955	60,887	1,377,035
1956	47,125	1,664,631
1957	53,452	1,173,215
1958	50,897	1,041,036
1959	47,736	1,211,721

Scrap mica is used principally as a raw material for producing ground mica. It is processed into a marketable form by grinding it to a powder to meet certain grain sizes, color and bulk density specifications. Two processes, dry grinding and wet grinding, are used to reduce the scrap mica to the proper size. Wet-ground mica differs from dry-ground mica in that it retains its sheen and has flakes with smooth, rounded edges in contrast to the abraded surfaces and torn, ragged edges of dry-ground mica.

Wet grinding is the more expensive of the two processes and only the better grades of scrap muscovite mica are used. A clean, white lusterous product is produced by this process which is used principally by paint, wallpaper and tire manufacturers. Dry grinding is much faster and inexpensive process and most North Carolina scrap mica is dry ground. Large tonnages of dry-ground mica are used as a filler and surface coating for roofing materials, as a filler in wallboard joint cements, and as an ingredient in paints. Smaller quantities are used in numerous products such as rubber, plastics, drilling mud, pipeline enamel and welding rods.

Producers of Ground Mica in North Carolina, 1959

Company	*Location*	*Product*
Asheville Mica Company	Biltmore	Dry
Deneen Mica Company	Newdale	Dry
DeWeld Mica Company	Spruce Pine	Dry
Diamond Mica Company	Spruce Pine	Wet
English Mica Company	Spruce Pine	Wet & Dry
Franklin Minerals Product Corp.	Franklin	Wet & Dry
Harris Clay Company	Spruce Pine	Dry
Kings Mountain Mica Company	Kings Mountain	Dry
Lawson-Boone Mica Company	Spruce Pine	Dry
David T. Vance	Plumtree	Wet

During the period 1954-1959, the average annual production of ground mica produced in North Carolina was 39,216 short tons, valued at $2,583,852, averaging $65.91 per ton. This average per ton cost does not reflect the difference in the cost of wet-ground, and dry-ground mica, as does the following quotations from the December 1959, issue of Engineering and Mining Journal: wet-ground mica, very fine, $140-$155 per ton; bulk sales and dry-ground, $30-$55 per ton; scrap, $20-$30 per ton.

Table 9. Ground Mica Sold or Used by Producers, 1954-1959

Year	Short Tons	Value
1954	41,253	$2,392,828
1955	42,008	2,672,263
1956	28,629	2,501,915
1957	42,873	2,870,714
1958	41,340	2,624,479
1959	39,195	2,446,912

Olivine

Olivine, a magnesium silicate, is a common constituent of basic igneous rocks called peridotites. In western North Carolina and adjacent northern Georgia, there are over 275 of these peridotite bodies, which constitute the largest reserves of olivine in the eastern United States. Although, many of these peridotite bodies are in various stages of alterations, there is available from 20 readily accessible deposits 230,000,000 tons of unaltered olivine, containing more than 45 percent magnesia, and one billion tons of partially altered dunite composed of 50 percent or more olivine averaging about 44 percent magnesia (Hunter, 1941, Forsterite Olivine Deposits of North Carolina and Georgia, N.C. Department of Conservation and Development, Bull. 41, p. 15).

The principal deposits of unaltered olivine occur in six general areas in western North Carolina. These are: (1) the Frank area, Avery County; (2) Toecane area, Yancey County; (3) the Canton-Democrat area, Haywood and Buncombe Counties; (4) Webster-Balsam area, Jackson County; (5) Ellijay area, Macon County; and (6) Buck Creek-Shooting Creek area, Clay County. The Webster-Balsam area contains the largest reserves of readily mineable olivine and has been the leading producing area in the State.

Olivine is presently used mainly as refractory bricks and in high temperature cements. It is marketed as crude blocks or in the ground form. Other uses include special foundry sands and as a source of magnesium salts. Olivine, because of its high magnesium content (up to 48 percent) and low cost, is a potential source of magnesium metal, vario magnesium compounds and special fertilizers.

Commercial production of olivine began in Nor Carolina in 1930, and although the annual produ tion has been comparatively small, the State h been a steady producer since that time. The avera annual production of olivine from 1954 through 19 was 11,137 short tons, valued at $166,777, averagi $15.09 per ton. This represents an increase of abo 107 percent in tonnage over the period 1946-19

Table 10. Production of Olivine in North Carolina, 1954-19

Year	Short tons	Value	Value per t
1954	*	*	*
1955	13,211	$211,389	$16.00
1956	16,740	210,304	12.56
1957	15,202	221,800	14.59
1958	6,824	94,500	13.85
1959	*	*	*

* Less than three (3) producers.

During the latter part of 1958 and the early pa of 1959, the North Carolina State College Miner Research Laboratory, at the request of Mr. Ray Wis man, undertook a pilot plant operation to produ olivine foundry sand from the Daybook deposit Yancey County. A satisfactory flotation process w worked out which will produce a product that w meet the required specifications for foundry sa The Wiseman Mining Company constructed a f tation mill at the quarry site late in 1960.

Producers of Olivine in North Carolina, 1954-1959

Company	Mine	County
Harbison-Walker Refractories Co.	Addie	Jackson
Balsam Gap Company	Balsam Gap	Jackson
C. R. Wiseman	Wray	Yancey
Wiseman Mining Company	Wray	Yancey

Perlite

North Carolina contains large amounts of volca flow and fragmental rock in the Carolina Slate Be which lies along the eastern edge of the Piedmo plateau. These rocks are so old and highly metam phosed that deposits of perlite, pumice, pumicite a volcanic cinder, such as are extensively worked the western part of the United States, are not fou in the area. However, Carolina Perlite Company, In expanded imported perlite for use as a lightweig aggregate at its Gold Hill plant in Rowan Cour during most of the period 1954-1959.

Phosphate

It has been known for many years that phosphate s associated with certain rocks of Eocene and Mio-ene age in the Coastal Plain region of North Caro-na. From their limited occurrence in outcrops, these hosphate deposits have never been considered of ommercial importance and no attempt has been ade to mine them.

In 1952 the American Metal Company obtained a ase from the State covering phosphate beneath e Pamlico River in Beaufort County. Considerable rilling and other exploration was done in connection ith this lease. A phosphorite formation was found a number of drill holes, but it was overlain by too uch overburden to be mined or dredged by conven-onal methods and the American Metal Company ncelled its lease in May 1953.

Subsequent ground-water studies by the U.S. Geo-gical Survey, in cooperation with the North Caro-na Division of Mineral Resources, proved the phos-horite deposits in Beaufort County and vicinity to much more extensive than previously believed. e phosphorites were found to underlie an area of proximately 450 square miles and to be overlain by to 250 feet of strata. These phosphorite deposits unconformably on limestone of Eocene age, are nconformably overlain by late Miocene marl and e tentatively considered to be of middle Miocene e. The total thickness of the phosphorite formation roughout the area ranges from a few feet to nearly feet and averages 30 to 40 feet.

According to Brown (1958, The Relation of Phos-orites to Ground Water in Beaufort County, North rolina, Econ. Geol., Vol. 53, No. 1, p. 85) the phos-orite formation "consists of phosphatic sands and tercalated shell limestones. The sands, composed pellets of brown sand-size collophane (probably rbonate-fluorapatite) and sand-size, flat-sized an-lar quartz with some silt, clay, and organic ma-rial, have a median diameter between 0.50 and 0.25 m. Chemical analyses of representative samples of raw sand show a variation in P_2O_5 content from o 31 percent. The P_2O_5 content is apparently pro-rtionate to the collophane content throughout the ea".

Early in 1956, Kennecott Copper Company, rough its exploration branch, Bear Creek Mining ompany and Sun Oil Company, through General ude Oil Company, became interested in the area derlain by the phosphorite deposits. Both com-nies did considerable prospecting in the area in 1957 and took up leases on a large acreage of private lands. Both companies also expressed an interest in leasing State-owned lands in the area.

In March, 1958, Bear Creek Mining Company, announced that it was withdrawing its exploration unit from the area and would cancel most of its leases obtained from private land owners. General Crude Oil Company, which also had leases on several thousand acres, continued exploration on a limited scale until about October 1958, when it also withdrew from the area.

The fact that the phosphorite deposits are buried by excessive overburden and cannot be recovered by conventional mining methods, probably accounts for the withdrawal of the interested mining companies from the area. However, the phosphorite deposits in Beaufort County and vicinity are perhaps the state's most important undeveloped mineral resource, and have the potential of becoming of great economic importance.

Sand and Gravel

Sand and gravel occurs throughout North Carolina, deposits having been worked in practically every county in the State at one time or another. The most important commercial deposits are those in the Sandhills region of Anson, Richmond, Moore, Hoke, Cumberland and Harnett Counties. However, important amounts of sand and gravel are obtained from the flood plains and stream channels along the major drainage systems in the Piedmont and Mountain regions.

Most of the sand produced is used as an aggregate in the building and construction trade, but some is used as engine sand, molding sand, filter sand and grinding and polishing sand. A high silica sand used in glass making is produced in the Spruce Pine district as a byproduct from feldspar flotation. Gravel is used mainly in building, paving and as railroad ballast. Some high-silica gravel is used for chemical purposes.

During the period covered by this report, sand and gravel accounted for about 15 percent of the total mineral production in the State and was exceeded only by stone in both tonnage and value. The average annual production was 7,543,435 tons valued at $6,118,983, or about $0.81 per ton. This represents an increase of 21 percent in tonnage and 46 percent in value over the period 1946-1953. In 1959 the value of sand and gravel reached an all-time high of $7,426,113 and was just slightly below the all-time high in tonnage.

Table 11. Sand and Gravel Sold or Used by Producers, 1954-1959

Year	Short Tons	Value	Value per ton
1954	7,441,200	$5,508,284	$0.74
1955	7,785,741	5,911,223	0.76
1956	7,580,593	6,264,135	0.83
1957	6,829,351	5,724,203	0.84
1958	7,043,852	5,879,943	0.83
1959	8,579,875	7,426,113	0.87

During 1959, commercial sand and gravel was produced in 15 counties, by 42 companies operating in 46 pits. In addition to the commercial operations, the State Highway Commission, private contractors and concrete products manufacturers mined considerable tonnages of sand and gravel for their own use. Listed below are the leading producers of sand and gravel during 1959.

Principal Producers of Sand and Gravel—1959

Producers	Address	Location of Operation
Becker County Sand and Gravel Co.	Cheraw, S. C.	Cumberland, Harnett, McDowell
Bryan Rock and Sand Co.	Raleigh	Moore, Northampton, Wayne
Lessees of B. V. Hedrick Gravel and Sand Company	Lilesville	Anson
Cumberland Gravel and Sand Co.	Lilesville	Hoke
Grove Stone and Sand Co.	Swannanoa	Buncombe
Nello L. Teer Company	Durham	Harnett, Wayne
N. C. Highway Commission	Raleigh	Various Counties
Pleasents Sand & Supply Company	Pinehurst	Moore
Sale and Alexander	Waynesville	Haywood
W. R. Bonsal Company	Lilesville	Anson

Stone

Stone is the principal mineral product of the State, averaging about 40 percent of the annual value and tonnage. During the period 1954-1959, the average annual production of stone was 11,732,354 tons, valued at $17,996,888. This represents an increase of 67 percent in tonnage and 63.6 percent increase in value over the period 1946-1953.

Table 12. Stone Sold or Used by Producers in North Carolina, 1954-1959

Year	Short tons	Value	Average Value	Percent State Total
1954	10,133,728	$15,625,331	$1.54	37.5
1955	10,903,366	16,532,910	1.52	40.1
1956	11,350,325	17,142,216	1.51	41.9
1957	12,711,164	19,246,784	1.51	51.1
1958	12,436,543	19,132,090	1.54	47.9
1959	12,859,000	20,302,000	1.58	49.7

Most of the production is derived from the crystalline rocks in the Piedmont and Mountain regions and includes granite, gneiss, slate, quartzite, limestone, marble and traprock. Over 85 percent of the value of the stone marketed during the period un consideration was as crushed stone, and the avera value per ton was $1.39.

Table 13. Crushed Stone Sold or Used by Producers North Carolina, 1954-1959

Year	Short Tons	Value	Average Va per To
1954	10,058,837	$14,165,790	$1.41
1955	10,816,282	14,979,443	1.38
1956	11,241,829	15,280,646	1.36
1957	12,566,838	17,217,112	1.37
1958	12,267,484	17,388,194	1.42
1959	12,513,715	17,560,488	1.40

Although a wide variety of rocks are quarried the State, granite and related crystalline rocks c stitute the principal commercial stone deposits a in 1959, North Carolina was the second larg producer of granite in the United States. Grani rocks occur throughout most of the State, but a lar percentage of the current production comes from central Piedmont section which includes Gast Mecklenburg, Lincoln, Cabarrus, Iredell, Rowan, D vie, Davidson, Forsyth, Guilford, Alamance, Casw and Person Counties. Important bodies of gran also occur along the western edge of the Coas Plain, especially in Wilson County, and in the nor eastern part of the Piedmont comprizing Wa Franklin, Warren, Vance and Granville Count Sizeable bodies of granite are present in the we ern Piedmont section in Stokes, Yadkin, Clevela Gaston, Polk and Rutherford Counties and les amounts in Wilkes, Catawba, Caldwell and Alexan Counties. Massive granites of the Piedmont ty are relatively rare in the Blue Ridge Mountains ar however, granite gneisses are common in cert areas. Among the more important occurrences those in Swain, Henderson, Transylvania, Clay a Macon Counties. Other deposits are found in Jacks Madison, Watauga and Ashe Counties.

Table 14. Granite Sold or Used by Producers in No Carolina 1954-1959

	Dimension Stone		Crushed Stone	
Year	Short tons	Value	Short tons	Valu
1954	28,434	$1,169,565	6,990,173	$ 9,897,
1955	36,446	1,232,304	7,878,491	11,004,
1956	34,671	1,388,150	8,351,953	11,468,
1957	27,597	1,365,975	9,454,310	12,835,
1958	30,245	1,089,337	8,184,281	11,939,
1959	54,408	1,794,441	8,460,497	11,911,

Extensive deposits of limestone and marble not common in North Carolina. However, comm

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Raleigh

ial deposits of crystalline limestone occur in re-tricted areas in the Piedmont and Mountain sections, nd shell limestones and marls are present in parts f the Coastal plain. All of the major deposits have een quarried at one time or another, most of the tone being marketed as crushed stone. Dimension tone, terrazzo chips and agricultural limestone are roduced in lesser amounts. During the period cover-d by this report crushed limestone accounted for pproximately 19 percent of the tonnage and 17 ercent of the value of the total stone quarried in he State.

able 15. **Production of Crushed Limestone in North Carolina, 1954-1959**

ear	Short Tons	Value	Value per ton
954	1,825,093	$2,534,277	$1.39
955	2,144,174	2,944,218	1.37
956	2,264,876	3,037,560	1.34
957	2,617,303	3,673,414	1.40
958	2,249,481	3,171,139	1.41
959	2,267,761	3,285,560	1.45

Dimension stone is a relatively small, but con-stent part of the stone industry in North Carolina. ranite, marble and slate are the principal rock pes used, but some quartzite and sandstone are ed from time to time. During the period covered this report, dimension stone accounted for 0.3 rcent of the average annual tonnage of stone quar-ed and 9 percent of the value.

Tble 16. **Production of Dimension Stone in North Carolina, 1954-1959**

Yar	Short Tons	Value
154	29,443	$1,265,407
155	38,984	1,332,538
156	37,100	1,552,677
157	35,617	1,823,742
158	37,725	1,613,237
159	63,396	2,135,593

The principal producers of dimension stone are the Nrth Carolina Granite Corporation, Harris Granite Qarries Company and the Columbia Marble Compny.

1959 was a year of considerable change in the or-gization of the crushed rock industry in North Crolina. Consolidation and mergers involved prac-tilly all of the major quarries in the State. Superior Sne Company and Bryan Rock and Sand Company we acquired by American-Marietta Company and a now operated as the Superior Stone Division of American-Marietta. Vulcan Materials Company purchased the quarries of W. E. Graham and Sons, Greystone Granite Quarries, Piedmont Quarry Company and Pioneer Quarry Company. These quarries will be operated as the W. E. Graham and Sons, Division of Vulcan Materials Company. The above acquisition involved 33 or more pits and quarries.

Principal Producers of Stone in North Carolina, 1959

Company	*Quarry*	*County*	*Product*
Ararat Products Co.	Unknown	Alleghany	Crushed granite
	Unknown	Surry	Crushed granite
Cogdill Limestone Co.	Cogdill	Henderson	Crushed limestone
Columbia Marble Co.	Marble	Cherokee	Dimension marble
Denton Flagstone Co.	Denton area	Davidson	Building slate
Fletcher limestone Co.	Fletcher	Henderson	Crushed limestone
W. E. Graham & Sons	Danville	Caswell	Crushed granite
	Piedmont	Forsyth	Crushed gneiss
	No. 421	Forsyth	Crushed granite
	North	Forsyth	Crushed gneiss
	Stokesdale	Guilford	Crushed granite
	Greystone	Vance	Crushed gneiss
Harris Granite Quarries	Collins	Rowan	Dimension granite
	Unknown	Rowan	Dimension granite
	Balfour	Rowan	Dimension granite
Jacobs Creek Flagstone Company	Jacobs Creek	Davidson	Dimension slate
	Woodward	Montgomery	Building slate
Macon Construction Co.	Penrose	Transylvania	Crushed gneiss
Nantahala Talc & Limestone Company	Nantahala	Swain	Crushed limestone
Nello L. Teer Co.	Greshmans Lake	Wake	Crushed granite
	Teer	Durham	Crushed diabase
	Princeton	Johnston	Crushed rhyolite
	New Bern	Craven	Crushed limestone
North Carolina Granite Corporation	Mt. Airy	Surry	Dimension granite
State Highway Commission	Numerous quaries in various counties		Crushed granite
Stone Mining Company	Cycle	Yadkin	
Superior Stone Co.	Mebane	Alamance	Crushed greenstone
	Hickory	Catawba	Crushed gneiss
	Gaston	Gaston	Crushed granite
	Buchanan	Guilford	Crushed granite
	McLeansville	Guilford	Crushed granite
	Jamestown	Guilford	Crushed granite
	Pomona	Guilford	Crushed granite
	Pineville	Mecklenburg	Crushed granite
	Charlotte	Mecklenburg	Crushed granite
	Reidsville	Rockingham	Crushed gneiss
	Woodleaf	Rowan	Crushed granite
	Roseville	Wake	Crushed granite
	Crabtree	Wake	Crushed gneiss
	Neverson	Wilson	Crushed granite
	Elm City	Wilson	Crushed granite
	Farmer (?)	Randolph	Crushed slate
	Bakers	Union	Crushed slate
	Kings Mt.	Cleveland	Crushed limestone
	New Bern	Craven	Crushed shell limestone
	Belgrade	Onslow	
E. B. Towles	Castle Hayne	New Hanover	

Quartz

Quartz, commercially referred to as silica, is an important mineral resource that has many industrial uses. It is also the most widespread of all minerals, but commercial deposits of sufficient size and purity are restricted. Large deposits of quartz occur chiefly as massive veins, sand, sandstone, quartzite and as segregations in pegmatites. The most important uses of quartz are in pottery, scouring soaps, glass, paint, wood filler, tooth powders, sandpapers, flux, chemical ware, in various types of lenses, and in the manufacture of ferrosilicon and silicon metal.

There are large deposits of quartz in various sections of North Carolina. Some of these deposits are of sufficient size and grade to qualify as high silica deposits. However, most of them cannot meet the requirements of high silica material without some beneficiation. At the present time, most of the production of high-silica material is from deposits of sand and gravel near Lilesville, Anson County, as a byproduct of feldspar flotation from the Spruce Pine district, and from massive quartz veins in Montgomery County.

During the latter part of the period covered by this report, several industries which use high-silica material as a basic raw material, were located in the State. Two glass plants, a fiber-glass plant and a silicon metal plant, were constructed and put into operation during 1958, 1959 and the first half of 1960. These plants represent an initial investment of approximately $30,000,000. In addition, about $18,000,000 has already been invested in expansions.

The Laurens Glass Works, Inc., located at Henderson, Vance County, and the Ball Brothers plant, located at Asheville, Buncombe County, produce a wide variety of quality bottles and jars for the food, beverage, chemical and pharmaceutical industries. The Pittsburg Plate Glass plant at Shelby, Cleveland County, is one of the largest fiber-glass plants in the United States. It has a capacity of 40,000,000 pounds of glass yarn per year. E. I. du Pont de Nemours plant at Brevard, Transylvania County, is a leading producer of silicon. It has an annual capacity of 50,000 pounds of ultra-high-purity silicon and 20,000 pounds of solar grade silicon.

At the present time only a small percentage of high-silica material used by these new industries is coming from North Carolina. However, the presence of these industries plus the prospects of similar plants locating in the State, presents a large potential market for the high-silica resources of North Carolina.

Talc and Pyrophyllite

North Carolina has been a producer of both talc and pyrophyllite for many years. Both minerals were produced each year of the period 1954-1959.

Two types of talc deposits occur in North Carolina. One type consists of lens-shaped bodies associated with dolomitic crystalline limestones. The talc in such deposits is high-grade material that is either ground into powder or cut into crayons for industrial use. Deposits of this type located in Cherokee County were mined throughout the period 1954-1959. The other type consists of irregular bodies formed by the alteration of basic magnesian rocks. Deposits of this type occur chiefly west of the Blue Ridge Mountains but some deposits are found as far east as northern Wake County. These deposits are low-grade and consists of talc associated with soapstone and other minerals. No production was made from these deposits during the period covered by this report.

Pyrophyllite deposits occur along the eastern edge of the Piedmont Plateau in Moore, Montgomery, Randolph, Chatham, Orange, Alamance and Granville Counties. North Carolina is the leading producer of pyrophyllite and is third in the nation in the production of talc and pyrophyllite combined.

All of the talc and most of the pyrophyllite produced in North Carolina is either cut into crayons or ground to powder and shipped our of the State for industrial uses. Pyrophyllite refractories are, however, manufactured at Pomona, Guilford County, by the North State Pyrophyllite Company.

Table 17. Tonnage and Mine Value of Talc and Pyrophyllite Produced in North Carolina, 1954-1959

Year	Tons	Value
1954	112,704	$338,428
1955	125,206	571,689
1956	125,487	529,205
1957	120,905	557,850
1958	126,158	613,779
1959	127,296	647,348

Producers of Talc and Pyrophyllite in 1959

Company	Address	County
Talc		
Hitchcock Corporation	Murphy	Cherokee
Minerals and Metals Corp.	Murphy	Cherokee
Pyrophyllite		
North State Pyrophyllite	Greensboro	Alamance, Orange
Carolina Pyrophyllite Co.	Greensboro	Granville, Moore, Randolph
Standard Mineral Co., Inc	Robbins	Moore
T & H Clay Co.	Carthage	Montgomery

Vermiculite

Vermiculite deposits of potential commercial importance are associated with a series of basic magnesian rocks (dunite) west of the Blue Ridge Mountains. The deposits extend northeast from Clay County to Avery County. Other occurrences in the upper Piedmont region are too small to be of value. Small

nounts of vermiculite were produced in 1954 and
955 but none has been produced in North Carolina
nce 1955. However, Zonalite Company, exfoliated
nported vermiculate at its High Point plant during
ie period of this report. Also, Lee-V-Lite, Inc., San-
ord, North Carolina, began exfoliating imported
ermiculite about 1959.

Mineral Fuels

Mineral fuels consist of Coal, natural gas and
troleum, and products derived from these materi-
s. During the period 1954-1959, North Carolina did
t produce any mineral fuels, but there was interest
d activity in exploring for coal, natural gas and
troleum.

Coal

The known coal deposits of North Carolina are
und in the Deep River Coal Field, which underlies
rts of Chatham, Lee and Moore Counties. In 1955,
e United States Geological Survey, published Pro-
ssional Paper 246, "Geology of the Deep River Coal
eld, North Carolina", by John a Reinemund, which
scribes the geology and coal reserves of this field
detail. This report contains 159 pages of text,
ures and tables, and eight geologic maps in a
cket. These maps consist of an areal geologic map
the field, structure section maps, maps of mines,
d maps showing the nature of the coal. Based on
ologic information, coal outcrops, mine sections,
d the records of 30 diamond-drill holes, it is esti-
ted the field contains approximately 101,989,000
ns of coal of which 50,185,000 tons are recoverable
der present economic conditions. The coal is bi-
minous and contains 33 percent volatile matter,
percent fixed carbon and 6 to 9 percent ash, and
ch of it is coking. The heat value is slightly
excess of 14,000 B.t.u.

The coal field which is elongated in a northeast-
thwest direction is bordered on the northwest
l southeast sides by northeast-southwest trend-
faults which are well established. However, there
a number of minor cross faults that trend in a
theast direction and are not so well established.
s faulting has presented difficult problems in
l mining.

July 1959, the Division of Mineral Resources,
empted to locate these cross faults by a geophysi-
survey. It was thought that electro-resistivity
ipment might locate the minor cross fault. The
lts obtained between July 1, 1959 and July 20,
19, were unsatisfactory and the survey was dis-
inued.

During the period of this report only one attempt was made to mine coal in the State. During the summer of 1958, Glenn Arter of Charlotte attempted strip mining for coal in the northern part of Moore County a short distance south of Carbonton, without success.

Oil and Gas

North Carolina is not a producer of oil or gas. However, between July 1, 1924 and June 30, 1960, a total of 35 exploratory wells were drilled for oil and gas. All of these wells were located in the eastern half of the Coastal Plain. No oil or gas was found in any of these wells. Twenty one of these wells were drilled between July 1, 1924 and the end of December 1953. During the years 1954-1955 and 1956, very little interest was shown in exploring for oil and gas in the State, but interest was renewed in 1957 and some drilling was done in 1959 and 1960.

The only part of North Carolina that contains geologic conditions which offer possibilities for the accumulation of oil and gas is the eastern half of the Coastal Plain. In that area, all mineral deposits beneath the bottoms of sounds, rivers, creeks and other waters, are the property of the Department of Conservation and Development. On October 28, 1957, Mr. J. E. Fitz-Patrick of Fort Worth, Texas, was granted a lease to explore for oil, gas and sulphur beneath the bottoms of sounds, rivers, creeks and other waters in that part of the Coastal Plain, north and east of a line from the courthouse in New Bern to the courthouse in Beaufort and east of the 77th meridian of longitude. Mr. Fritz-Patrick died in March 1958 before any drilling was done. In the fall of that year, the Department of Conservation and Development assigned his lease to the Coastal Plains Oil Company, a North Carolina Corporation.

Between April 1, 1959 and June 30, 1959, Coastal Plains Oil Company drilled seven exploratory wells in the area, all of which were located around the western half of Lake Mattamuskeet in Hyde County. These wells were shallow and were drilled primarily to obtain information on the structure and lithology of the formations penetrated. One well bottomed at a depth of 1635 feet, another at 1685 feet and the remaining five all reached the same depth, 2005 feet. None of the wells reached basement (crystalline rock) and no oil or gas was found.

In May 1959, Bryant P. Seay of Houston, Texas, drilled two exploratory wells for oil and gas in the Hoffman Forest of Onslow County, about ten miles north of Jacksonville, the county seat. One of these wells bottomed in crystalline rock at a depth of 1430 feet, and the other bottomed in crystalline rock at a depth of 1335 feet. No oil or gas was found in either well.

In September 1959, American Mining and Development Corporation of New York City, drilled two wells in the Coastal Plain, one in Bladen and one in Pender County. The well in Bladen County was located about three miles southeast of Kelly and about one-half mile west of an unnumbered state road. This well reached a depth of 765 feet, but basement (crystalline rock) was encountered at 690 feet. The well in Pender County was located a few hundred feet north of South River and a short distance east of State Highway 53. It reached a depth 720 feet but entered basement (crystalline rock at a depth of 690 feet. No oil or gas was found in either of these wells.

In June 1960, Peter Henderson Oil Company of New York City, drilled three exploratory wells in the Hoffman Forest of Jones and Onslow Counties, about ten miles north of Jacksonville, the county seat of Onslow County. One of these wells was located in Jones County and the other two were located in Onslow County. Well No. 1, located in Onslow County, reached a depth of 1232 feet. Well No. 2, located in Jones County, reached a depth of 1239 feet. Well No. 3, located in Onslow County, reached a depth of 1328 feet. Neither of these wells reached basement (crystalline rock) or showed any signs of oil or gas.

VALUE OF THE MINERAL INDUSTRY TO NORTH CAROLINA

Tables 1 and 2 and Figures 1 and 2, in the first part of this report record the mine value of the mineral production of North Carolina in recent years. Most minerals require processing to some extent to be usable or marketable. In only a few cases is any value added by processing included in the values recorded in these tables and figures. Minerals are becoming more and more important in manufacturing industries. Any value added by processing minerals to make them useful in manufacturing as well as the values added by manufacturing are a part of the value of the mineral industry to the State.

Except for the construction materials, common clays, sand and gravel, and stone, most of the minerals produced in North Carolina are shipped to out of State processing plants and markets. Regardless of where they are used, the construction materials require some processing to make them usable. In the case of sand and gravel, and stone, the processing which consists of washing, screening, crushing, shaping and sizing is included in the sale price. Considerable sand, gravel and stone are used by manufacturing industries in the State, but no part of the value created by such manufactured products is credited to the mineral industry of the State.

Clays, except kaolin, require little or no processing before being used in the production of brick, drain tile, sewer pipe and other products. As a result, the value of such clays as they come from the mines is estimated at about 60 cents per ton, and 60 cents times the number of tons produced is the value credited to the common clay industry of the State. During the period 1954-1959 this value averaged $1,950,612 for each year of the period. It is generally recognized that ordinary clays and shales have no value until they are manufactured into brick, drain tile, sewer pipe and other products. As shown below, the value of such products manufactured in North Carolina from local clays and shales amounted to between 19 million and 29 million dollars each year of the period 1954-1959.

Copper and tungsten concentrates are shipped to eastern plants for smelting and refining. No values for these materials are available other than the value of the concentrates which is included in undistributed in Table 1. However, the processing plants located at Ore Knob, Ashe County and near Townsville, Vance County, make important economic contributions to the areas in which they are located. Lithium ore imported from Canada, as well as North Carolina ore, is processed at Bessemer City, Gaston County and Kings Mountain, Cleveland County. The only values available on lithium minerals is the value of concentrates which are included in undistributed in Table 1. Here also, the large processing plants at Bessemer City and Kings Mountain, make major economic contributions to those areas.

North Carolina is the leading producer of sheet mica, practically all of which is shipped out of the State. The only figures available on the value of sheet mica are those in Table 1 and Table 7 above.

Minerals that are produced and ground or shaped in North Carolina before being shipped to out of State manufacturing plants include feldspar, scrap mica, quartz, olivine, talc and pyrophyllite. The value added to most of these is summarized below.

Clays and Shales

North Carolina is a leading producer of clays and shales all of which are used in the State in the manufacture of brick, tile, sewer pipe, lightweight aggregate and other products. In 1958, the last year for which figures are available, North Carolina produced one of each three bricks manufactured in the southstern States and one out of each eleven brick manu- ctured in the United States. In that year it was urth in the nation with Ohio first, Pennsylvania cond, Texas third. Table 18 below shows the mine lue of clays and shales, the value of manufactured oducts, other than lightweight aggregate, and the lue added by manufacturing during the period 54-1959. The value of manufactured products was rnished by Mr. H. B. Foster, Manager, Brick and le Service, Greensboro, North Carolina.

ble 18. Value of Clays and Clay Products, 1954-1959

r	Mine Value Clays and shales	Value Manufactured products*	Value added by Manufacturing
54	$2,519,721	$19,182,760	$16,663,039
55	2,792,081	24,276,371	22,484,290
56	2,026,709	25,145,350	23,118,641
57	2,050,000	25,673,284	20,619,284
58	1,520,007	24,738,318	23,218,311
59	1,791,154	28,964,448	27,173,294

xcludes value of lightweight aggregate.

During the period 1954-1959, the average annual lue of clays and shales produced in North Carolina s $1,850,612. During the same period the average nual value of products manufactured from clays d shales, excluding lightweight aggregate, was 4,163,422. The average annual value added during s period, exclusive of the value of lightweight gregate, was $22,212,810.

Feldspar

North Carolina is the leading state in the produc- n of feldspar and during the period 1954-1959 nished approximately 45 percent of the feldspar duced in the United States. All of the feldspar duced in North Carolina is shipped to out of State cessing plants and markets. Some feldspar is pped in the crude form and some in the ground m and some in the ground form. Table 19 below es the value of crude feldspar sold, the value of und feldspar sold and the value added by grinding.

le 19. Value of Crude and Ground Feldspar, 1954-1959

Yer	Crude	Ground	by Grinding
94	$2,220,707	$3,123,096	$ 902,389
95	2,184,793	3,850,265	1,665,472
96	3,191,559	4,044,653	853,094
97	2,728,153	3,406,055	677,902
98	2,519,713	3,120,619	500,906
99	2,934,552	3,251,522	317,000

uring the period 1954-1959, the average annual ae of crude feldspar was $2,629,913. During the e period, the average annual value of ground spar was $3,466,035. The average annual value ed during this period by grinding was $836,127.

Mica

North Carolina is the leading State in the production of sheet and scrap mica. In recent years it has produced approximately 75 percent of the domestic sheet mica and over half of the scrap mica. In 1959, the production of sheet mica declined to 72 percent of the total domestic production, while the production of scrap mica declined to approximately 48 percent of the total domestic production. North Carolina is an important fabricator of film and block mica, but so much of the State's production is exported that no accurate figures are available on the value added to sheet mica by processing.

Most of the scrap mica produced in North Carolina is ground in the State. Table 20 below shows the value of scrap and ground mica produced in North Carolina and the value added by grinding during the period 1954-1959.

Table 20. Value of Scrap and Ground Mica, 1954-1959.

Year	Mine Value	Ground Value	Value added by grinding
1954	$1,457,122	$2,392,828	$ 935,506
1955	1,377,035	2,672,263	1,295,228
1956	1,664,631	2,501,915	837,284
1957	1,173,215	2,870,714	1,697,499
1958	1,041,036	2,624,479	1,583,443
1959	1,211,721	2,446,912	1,235,191

During the period 1954-1959, the average annual value of scrap mica was $1,320,783. During the same period the average annual value of ground mica was $2,584,862, while the average annual value added by grinding was $1,264,079.

Talc and Pyrophyllite

North Carolina is the leading State in the production of pyrophyllite and ranks third in the production of talc and pyrophyllite combined. The North State Pyrophyllite Company, Pomona Guilford County, uses its mine output in the manufacture of pyrophyllite refractories. Since there is only one producer of pyrophyllite refractories in the State, the value of manufactured refractories cannot be revealed. All of the talc and most of the pyrophyllite cut and ground by merchant mills is shipped to out of State markets. One company, Mid State Tile Company, Lexington, North Carolina, uses some North Carolina pyrophyllite in the manufacture of ceramic tile. Table 21 shows the annual mine value of talc pyrophyllite, the annual value of ground and cut talc and pyrophyllite and the annual value added by grinding and cutting.

Table 21. Value of Crude and Ground Talc and Pyrophyllite 1954-1959

Year	Mine Value	Ground Value	Value added by Grinding
1954	$388,428	$1,771,778	$1,383,350
1955	571,689	1,999,560	1,427,871
1956	529,205	1,921,834	1,393,629
1957	557,850	2,003,189	1,445,339
1958	613,779	2,078,176	1,464,397
1959	647,348	2,251,205	1,603,857

During the period 1954-1959, the average annual value of crude talc and pyrophyllite was $551,383. During the same period the average annual value of ground and cut talc and pyrophyllite was $2,004,290, while the average annual value added by grinding and cutting was $1,452,907.

Lightweight Aggregate

North Carolina is an important producer of lightweight aggregate, some of which is produced from raw materials mined in the State, and some of which is produced from raw materials shipped into the State. Complete figures are not available on all phases of the lightweight aggregate manufacturing industry in North Carolina and the partial figures available cannot be revealed without disclosing confidential company data. However, it is estimated that the value of lightweight aggregate produced in North Carolina in 1959, exclusive of the mine value of the raw materials used, was approximately $1,100,000.

Manufacturers of Lightweight Aggregate in North Carolina

Company	Plant
Carolina Perlite Company, Inc.	Gold Hill
Carolina Tuff-Lite Corporation	Salisbury
Lee-V Lite, Inc.	Sanford
Southern Lightweight Aggregate Corporation	Aquadale
The Zonolite Company	High Point

Cement Products

The cement products industry in North Carolina has experienced tremendous growth during the past few years and continues to become increasingly important each year. North Carolina produces large quantities of sand, crushed stone aggregate and screenings, and lightweight aggregate used in all types of cement products. Only the cement used is not produced in the State.

There is a wide variety of cement products now being produced, but the most important are concrete blocks and bricks, pipe, septic tanks, precast and prestressed structural beams, piling, and roof and floor slabs. In addition, large quantities of re y mixed concrete are used annually in the buil g and construction trade.

Unfortunately, no statistics are presently l lected on the cement products industry and th e is no way to reliably estimate its value to the m n eral industry in North Carolina. However, Mr. Un r hill, Secretary to the North Carolina Concrete a sonry Association, estimates that in 1959 there w e 70 producers of concrete blocks in the State. p proximately 60 million 8 x 8 x 16 inch block or b k equivalents were produced, valued at some 13 il lion dollars. Of the concrete blocks produced, p proximately 75 percent were made from lightwe t aggregate. From this, its appears that lightwe t aggregate blocks, or equivalents, valued at $9,7 ,000 were produced in North Carolina during the y r 1959. No figures showing the value of the li weight aggregate used in these blocks are availa e.

STONE, CLAY AND GLASS MANUFACTUR G IN NORTH CAROLINA

The overall growth of the mineral industry n North Carolina during the past six years and s increasing importance to the general economy f the State is clearly reflected in the following t e showing the value of stone, clay and glass ma facturing in the State. These figures were ta n from the 1954-1960 editions of "The Blue Boo f Southern Progress", which is an annual publica n of "The Industrial Development and Manufactu s Record". No detailed figures are available to i cate the value of the minerals in these products t were mined in North Carolina. It was evidently la e and should continue to grow.

Table 22. Value of Stone, Clay and Glass Products M factured in North Carolina, 1954-1959

Year	Value
1954	$ 57,000,000
1955	76,000,000
1956	80,000,000
1957	83,000,000
1958	85,000,000
1959	119,000,000

During the six-year period covered by this port, the average value of stone, clay and glass ducts manufactured in North Carolina was $83,0 000.

The following graph (Fig. 3) further shows t growth in the stone, clay and glass manufactu i of North Carolina for the 20-year period, 1939-1

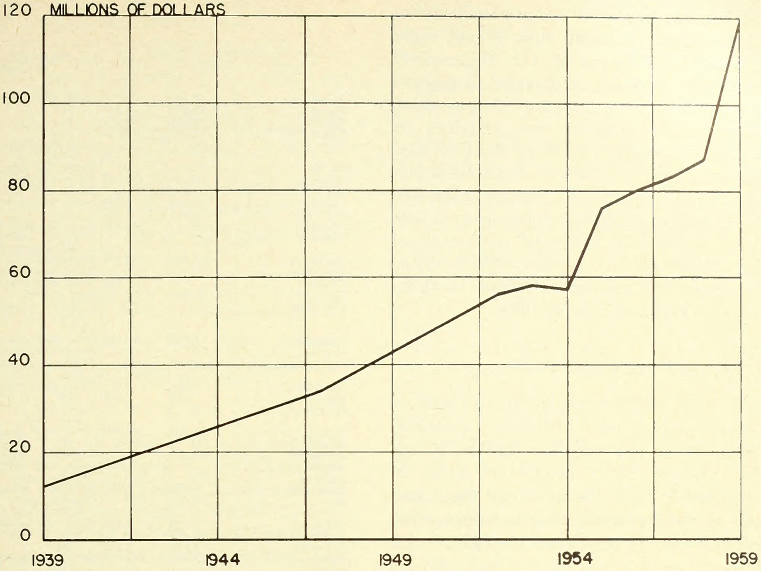

FIGURE 3. STONE, CLAY AND GLASS MANUFACTURING IN NORTH CAROLINA, 1939-1959

As indicated in Table 22 and Figure 3, above, Nrth Carolina is fast becoming an important manufcturer of stone, clay and glass products. It is eimated that there are more than 100 plants of all tpes engaged in manufacturing products from mineal raw materials in the State. A complete list of sch plants is not available. However, the following ae the more important producers of relatively high pced products chiefly from imported ores and mineals. Some of them are using small amounts of local mnerals and their presence in the State is a strong iucement for mining companies in the State to pduce the sort of raw materials they need.

Manufacturers of Mineral Products

Copany	*Location*	*Product*
Alinum Company of America	Baden	Aluminum
Ba Brothers, Inc.	Asheville	Glass containers
E dupont de Nemours Company, Inc.	Brevard	Silicon
Grt Lakes Carbon Corporation	Morganton	Graphite
Hyan Porcelain, Inc.	Hickory	Pottery, porcelain
Laens Glass Works, Inc.	Henderson	Glass containers
Mi State Tile Company	Lexington	Ceramic tile
Pitburg Plate Glass Company	Shelby	Fibre glass

Values Added by Processing

s shown on page 2 above, the average annual me value of minerals produced in North Carolina duing the period 1954-1959, was $40,346,000.

The established values added each year of the period by manufacturing mineral products in North Carolina or by processing North Carolina minerals in the State were as follows:

Clays and shales (brick, tile sewer pipe)		$22,212,810
Clays, shales and others (lightweight aggregate)		1,100,000
Feldspar (ground)		836,000
Mica (ground)		1,264,079
Talc and pyrophyllite (cut and ground)		1,452,907
Value added	Total	$26,865,923
Average mine value all minerals		40,346,000
	Grand Total	$67,211,923

If the values added by processing other minerals produced in the State and the value of stone and glass products manufactured in the State from North Carolina minerals were available, and added to the above figure of $67,211,923, it is estimated that the average annual value of the mineral industry to the economy of North Carolina would be in excess of $100,000,000.

APPENDIX

The United States Bureau of Mines 1959 Minerals Yearbook, Volume III, Area Reports contains a chapter entitled, "The Mineral Industry of North

Carolina", which was prepared under a cooperative agreement for collecting mineral data, except fuels, between the Bureau of Mines of the U.S. Department of Interior and the Division of Mineral Resources of the North Carolina Department of Conservation and Development. This chapter was prepared by James L. Vallely, Commodity-Industry Analyst, U.S. Bureau of Mines; Jasper L. Stuckey, State Geologist of North Carolina and Mildred E. Rivers, Statistical Assistant, U.S. Bureau of Mines. That part of this chapter entitled, "Review by Counties" is reproduced below in order to acquaint the reader with the more important minerals and mining activities in those counties that produced minerals in 1959.

REVIEW BY COUNTIES

Ninety-five of the 100 counties in North Carolina reported mineral production; Mitchell, Cleveland, Guilford, Ashe, and Anson were the leaders. In addition to the detailed county production listed in Table 12, considerable crude feldspar and sheet and scrap mica, also a small quantity of gem stones, were produced—all of undetermined county origin.

Alamance.—Superior Stone Co., a division of American-Marietta Co. (Burlington and Mebane quarries) and North Carolina State Highway & Public Works Commission crushed granite for concrete and roads. Boren & Harvey (Snow Camp mine) mined pyrophyllite for refractory and ceramic uses. Hanford Brick Co., Inc., mined miscellaneous clay for heavy clay products. The State highway commission mined paving sand.

Alexander.—The State highway commission mined 43,000 tons of paving sand. Ruth P. Stanley and Fred Allen collected a small quantity of gem stones (emerald, sapphire, quartz crystals, and hiddenite).

Alleghany.—Ararat Products Co. crushed 50,000 tons of granite for concrete and roads. Ruth P. Stanley collected a few gem stones (manganite and quartz crystals).

TABLE 12.—Value of mineral production in North Carolina, by counties[1]

County	1958	1959	Minerals produced in 1959 in order of value
Alamance	$17,830	(2)	Granite, talc, miscellaneous clay, sand and gravel.
Alexander	(2)	$14,360	Sand and gravel, gem stones.
Alleghany		62,030	Granite, gem stones.
Anson	(2)	2,382,641	Sand and gravel, traprock.
Ashe	(2)	(2)	Copper, gold, silver, mica, sand and gravel.
Avery	(2)	(2)	Mica, kaolin, sand and gravel, feldspar, iron ore, gem stones.
Beaufort	38,100	(2)	Sand and gravel.
Bertie	13,200	3,000	Do.
Bladen	63,600	56,000	Do.
Brunswick	18,000	18,000	Do.
Buncombe	(2)	(2)	Sand and gravel, granite, mica, stones.
Burke	(2)	(2)	Sand and gravel, mica.
Cabarrus	20,000	103,683	Granite, sand and gravel.
Caldwell	(2)	(2)	Sand and gravel, mica.
Camden	1,500	1,050	Sand and gravel.
Carteret	1,050	1,575	Do.
Caswell	(2)	646,948	Granite, sand and gravel.
Catawba	(2)	(2)	Granite, miscellaneous clay, and gravel, mica.
Chatham	268,420	388,173	Miscellaneous clay, traprock
Cherokee	(2)	(2)	Talc, marble, granite.
Chowan		950	Sand and gravel.
Clay	24,500	70	Gem stones.
Cleveland	(2)	(2)	Lithium minerals, limestone, sand and gravel, miscellan clay.
Columbus	47,400	42,350	Sand and gravel.
Craven	(2)	(2)	Limestone, sand and gravel.
Cumberland	214,295	(2)	Sand and gravel, miscellan clay.
Currituck	1,750	9,030	Sand and gravel.
Dare	750	2,100	Do.
Davidson	(2)	(2)	Sand and gravel, slate, misce eous clay.
Davie	39,500	49,800	Sand and gravel.
Duplin	(2)	(2)	Do.
Durham	(2)	(2)	Traprock, miscellaneous clay.
Edgecombe		1,325	Sand and gravel.
Forsyth	(2)	(2)	Granite, sand and gravel.
Franklin	3,000	2,000	Sand and gravel.
Gaston	57,223	(2)	Granite, sand and gravel, mi laneous clay, mica.
Gates	1,500	2,250	Sand and gravel.
Graham	45,000		
Granville	3,142	5,332	Do.
Greene	$15,897	$27,000	Sand and gravel.
Guilford	2,814,261	(2)	Granite, miscellaneous clay, and gravel.
Halifax	26,600	(2)	Miscellaneous Clay, sand and gr
Harnett	(2)	(2)	Sand and gravel, miscellaneous
Haywood	(2)	(2)	Sand and gravel, gem stones,
Henderson	523,812	342,846	Limestone, miscellaneous clay.
Hertford	4,250	4,225	Sand and gravel.
Hoke	(2)	103,697	Do.
Hyde	400	740	Do.
Iredell	27,506	(2)	Sand and gravel, mica, gem st
Jackson	(2)	(2)	Olivine, mica.
Johnston	(2)	(2)	Traprock, sand and gravel.
Jones	21,822	20,979	Sand and gravel.
Lee	215,500	(2)	Miscellaneous clay, sand and gr
Lenoir	154,330	133,851	Sand and gravel.
Lincoln	15,870	15,521	Sand and gravel, gem stones.
Macon	154,503	(2)	Sand and gravel, mica, gem st
Madison	(2)		
Martin	7,500	5,370	Sand and gravel.
McDowell	(2)	(2)	Sand and Gravel, limestone.
Mecklenburg	(2)	(2)	Granite, sand and gravel.
Mitchell	(2)	(2)	Feldspar, mica, sandstone, sand gravel, gem stones.
Montgomery	(2)	(2)	Miscellaneous clay, talc, sand gravel, slate.
Moore	(2)	(2)	Talc, sand and gravel, miscellan clay, gem stones.
Nash	(2)	(2)	Sand and gravel.
New Hanover	(2)	(2)	Granite, sand and gravel.
Northampton	(2)	(2)	Sand and gravel.
Onslow	(2)	(2)	Limestone, sand and gravel.
Orange	(2)	(2)	Talc, granite.
Pamlico	1,050	3,600	Sand and gravel.
Pasquotank	4,750	900	Do.
Pender	4,000	4,000	Do.
Perquimans	500	3,000	Do.
Person	5,557	9,675	Do.
Pitt	(2)	(2)	Do.
Polk	60,100	1,200	Granite.
Randolph	(2)	(2)	Granite, traprock, talc, gem st
Richmond	17,500	4,825	Sand and gravel.
Robeson	(2)	(2)	Do.
Rockingham	(2)	(2)	Granite, miscellaneous clay, rock, sand and gravel.
Rowan	1,403,971	2,079,165	Granite, miscellaneous clay, and gravel, abrasive stones.
Rutherford	78,511	152,189	Sand and gravel, mica, gem st
Sampson	25,880	26,278	Miscellaneous clay, sand and g
Stanly	173,200	267,235	Miscellaneous clay, traprock, and gravel.
Stokes	(2)	(2)	Miscellaneous clay, mica, sand gravel.
Surry	(2)	(2)	Granite, sand and gravel, stones.
Swain	151,325	(2)	Limestone, feldspar.
Transylvania	(2)	(2)	Granite, sand and gravel, asbestos.

TABLE 12.—Value of mineral production in North Carolina, by counties[1]—Con.

County	1958	1959	Minerals produced in 1959 in order of value
rrell	400	....	
ion	(2)	(2)	Traprock, miscellaneous clay.
nce	(2)	(2)	Granite, tungsten, sand and gravel.
ake	(2)	(2)	Granite, sand and gravel, gem stones.
ashington	17,500	25,440	Sand and gravel.
atauga	62,674	6,997	Do.
ayne	(2)	(2)	Do.
ilkes	15,536	(2)	Granite, sand and gravel, mica gem stones.
ilson	(2)	(2)	Granite, sand and gravel.
dkin	(2)	(2)	Do.
ncey	570,573	302,339	Mica, sand and gravel, feldspar, olivine, gem stones.
ndistributed [1]	32,435,762	33,455,261	
Total	39,891,000	40,789,000	

Scotland and Warren counties are not listed because no production was orted.

Figure withheld to avoid disclosing individual company confidential ta; included with "Undistributed."

Included value of feldspar, mica, and gem stones tbat cannot be as- ned to specific counties and values indicated by footnote 2.

See footnotes at end of table.

Anson.—Anson County ranked fifth in value of ineral production. Lessees of B. V. Hedrick (Liles- lle mine), W. R. Bonsal Co. (Bonsal mine), and the ate highway commission mined 2,038,000 tons of ructural, paving, railroad ballast, and fill sand and avel. The State highway commission crushed 34,- 0 tons of traprock for concrete and roads.

Ashe.—Ashe County ranked fourth in value of neral production. Appalachian Sulphides, Inc. (Ore nob mine) recovered copper, gold, and silver. Six ca mines were operated. The leading producers re Aldridge & Jesse Callahan (Tucker mine), e Snyder (Duncan mine), and Alma Crowder (alter Houlk mine). The State highway commis- n mined 11,000 tons of paving gravel.

Avery.—Mica was produced at 32 mines. The ding producers of sheet mica were Joe L. Snyder (harlie Ridge mine), Benwood Mining Co. (Mill ce mine), and Avery Mining Co. (Avery mine). e leading producer of scrap mica was Harris Clay (Kaolin mine). Harris Clay Co. (Gusher Knob Kaolin mines) mined kaolin for whiteware, floor wall tile, refractories, plastics, and artificial asives.

he State highway commission mined 41,100 tons paving gravel. The Feldspar Corp. (Guy, Vance, Hicks mines) and Charlie Silver (Silver mine) duced crude feldspar. Ruth P. Stanley collected w gem stones (garnets).

ranberry Magnetite Corp., reopened the old Cran- y mine which had been idle since 1929, construc- new mill, and shipped a small quantity of mag- te to Birmingham, Ala.

Beaufort.—J. D. McCotter, Inc., and the State highway commission mined structural and paving sand.

Bertie.—The State highway commission produced 6,000 tons of paving sand.

Bladen.—The State highway commission mined 108,000 tons of paving sand.

Brunswick.—The State highway commission produced 18,000 tons of paving sand.

Buncombe.—Four operators mined structural, paving, and railroad ballast sand and gravel. The leading producer was Grove Stone & Sand Branch of B. V. Hedrick Gravel & Sand Co. The State highway commission (Weaverville quarry) crushed 20,000 tons of granite for concrete and roads. Three mica mines were operated in 1959. The leading producer was Ben F. and Oliver Reese (Indian Pott mine). G. L. Winslow and Herby Bolick collected a small quantity of gem stones (feldspar and kyanite.)

Burke.—A. P. Causby Sand & Stone Co. and the State highway commission mined paving sand and gravel. Stokes Buchanan (Stillwell mine) and H. Lee Medford (Noah Young mine) mined sheet mica. Great Lakes Carbon Corp. manufactured graphite at its plant in Morganton.

Cabarrus.—Lee White Gravel Pit and the State highway commission mined paving sand and gravel. The State highway commission crushed 60,000 tons of granite for concrete and roads.

Caldwell.—Miller Brothers Co. and the State highway commission mined paving sand and gravel. Conrad Pearch mined a small quantity of sheet mica.

Camden.—The State highway commission produced 3,500 tons of paving sand.

Carteret.—The State highway commission mined 3,500 tons of paving sand.

Caswell.—W. E. Graham & Sons, a division of Vulcan Materials Co. (Danville quarry) and the State highway commission (Ivy Bluff quarry) crushed 408,000 tons of granite for concrete and roads. The State highway commission mined 38,000 tons of paving sand.

Catawba.—Superior Stone Co. Division (Hickory quarry) crushed granite for concrete and roads. Statesville Brick Co. mined miscellaneous clay for heavy clay products. The State highway commission mined paving sand. Joe Lynn (Whitner mine) produced a small quantity of sheet mica.

Chatham.—Four mines produced miscellaneous clay for heavy clay products. The leading producers were Pomona Terra Cotta Co. and Boren Clay Products Co. (Gulf mine). The State highway commission (Goldston quarry) crushed some 105,000 tons of traprock for concrete and roads.

Cherokee.—Columbia Marble Co. (Pleasant Valley quarry) quarried dimension marble for rough, sawed, and cut interior stone and crushed marble for terazzo and other uses. Hitchcock Corp. (Nancy Jordan mine) and Minerals & Metals Corp. (Mulberry Gap mine) mined talc for crayons, textiles, toilet preparations, and other uses. The State highway commission (Dockery and Carringer quarries) crushed granite for concrete and roads.

Chowan.—The State highway commission mined 1,800 tons of paving sand.

Clay.—Fred O. Scruggs collected a few gem stones (ruby corundum in matrix).

Cleveland.—Cleveland County ranked second in value of mineral production. Superior Stone Co. Division (Kings Mountain quarry) crushed limestone for concrete and roads. Seventeen mica mines were operated in 1959. The leading producer of sheet mica was Joe L. Snyder (Campbell, Holiman, Hartman, Ledford, Workman, and Bailey mines). Kings Mountain Mica Co. (Moss and Patterson mines) and Foote mineral Co. (Kings Mountain mine) were the leading producers of scrap mica.

The State highway commission mined 44,000 tons of paving sand. Bennett Brick & Tile Co. mined 21,000 tons of miscellaneous clay for heavy clay products. Foote Mineral Co. mined and processed lithium minerals at Kings Mountain.

Columbus.—The State highway commission mined 80,600 tons of paving sand.

Craven.—Superior Stone Co. Division (New Bern quarry) and Nello L. Teer Co. (Shell quarry) crushed limestone for concrete and roads. Southern Sand Co., Inc., and the State highway commission mined structural and paving sand.

Cumberland.—Becker County Sand & Gravel Co. and the State highway commission mined structural, paving, and railroad-ballast sand and gravel. Ideal Brick Co. (Linden mine) mined miscellaneous clay for heavy clay products.

Currituck.—The State highway commission produced 30,000 tons of paving sand.

Dare.—The State highway commission min 7,000 tons of paving sand.

Davidson.—Jacob's Creek Flagstone Co., Inc., a Denton Flagstone Quarry quarried slate for stru tural millstock and flagging. The State highw commission mined 191,000 tons of paving sand a gravel. Cunningham Brick Co. (Thomasville min mined miscellaneous clay for heavy clay produc

Davie.—The State highway commission min 83,000 tons of paving sand.

Duplin.—James W. Kelly and the State highw commission mined structural and paving sand.

Durham.—Nello L. Teer Co. crushed traprock f concrete and roads. Borden Brick & Tile Co. min miscellaneous clay for heavy clay products.

Edgecombe.—The State highway commission mi ed 2,500 tons of paving sand.

Forsyth.—W. E. Graham & Sons Division crush granite for concrete and roads at the North Pie mont, South Fork, and No. 421 quarries. Ira Pope Sons, Inc., Paul Miller, and the State highway co mission mined structural and paving sand.

Franklin.—The State highway commission min 4,000 tons of paving sand.

Gaston.—Superior Stone Co. Division (Gast quarry) crushed granite for concrete and roa Kendrick Brick & Tile Co. mined miscellaneous cl for heavy clay products. The State highway comm sion mined 37,000 tons of paving sand. Harry Sou ard (Ramsey mine) and Millard Townsend (Husk mine) mined a small quantity of sheet mica.

Gates.—The State highway commission mir 7,500 tons of paving sand.

Granville.—The State highway commission p duced 7,500 tons of paving sand.

Greene.—The State highway commission mir 60,000 tons of paving sand.

Guilford.—Guilford County ranked third in va of mineral production. Superior Stone Co. Divis (McLeansville, Pomona, Buchanan, and Jamesto quarries) and W. E. Graham & Sons Divis (Stokesville quarry) crushed granite for concr and roads. Boren Clay Products Co. (Pleasant G den mine) mined miscellaneous clay for heavy c products. The State highway commission mined p ing sand. Zonolite Co. exfoliated vermiculite in plant at High Point.

Halifax.—Nash Brick Co. (Ita mine) mined misellaneous clay for heavy clay products. The State ighway commission mined paving sand.

Harnett.—Becker County Sand & Gravel Co. (Sener mine), Nello L. Teer Co., and the State highway ommission mined sand and gravel for structural, aving and filtration purposes. Norwood Brick Co. Lillington mine) mined miscelleous clay for heavy lay products.

Haywood.—Sale & Alexander (Waynesville mine) ined paving sand and gravel. Fred O. Scruggs colected a few gem stones (sapphires). Alta R. Stewart Big Ridge mine) mined a small quantity of sheet ica.

Henderson.—Fletcher Limestone Co. (Fletcher uarry) and Cogdill Limestone Co., Inc. (Cogdill uarry) crushed 197,000 tons of limestone for conete, roads, and other uses. Fletcher Brick Co., Inc. Fletcher mine) mined 62,000 tons of miscellaneous ay for heavy clay products.

Hertford.—The State highway commission mined 3,500 tons of paving sand.

Hoke.—Cumberland Sand & Gravel Co. (Vass mine ad the State highway commission mined 83,000 tons structural, paving, and fill sand and gravel.

Hyde.—The State highway commission mined 400 tons of paving sand.

Iredell.—Tarheel Construction Co. and the State ighway commission mined paving sand and gravel. Je Lynn (Stewart mine) mined a small quantity sheet mica. Ruth P. Stanley collected a small antity of gem stones (rutile).

Jackson.—Harbison-Walker Refractories Co. (Add mine) mined olivine for refractories. Nine mines poduced mica in 1959. The leading producers of seet mica were F. E. Stillwell (Stillwell mine) and Vlliam G. Ashe (Mack Presnell mine).

Johnston.—Nello L. Teer Co. (Princeton quarry) cushed traprock for concrete and roads. The State hhway commission mined 33,500 tons of paving sad.

Jones.—Simmons Marl & Lime Co. and the State hhway commission mined paving sand and gravel.

Lee.—Sanford Brick & Tile Co. (Colon mine), Brden Brick & Tile Co. (Sanford mine), and Hanford Bck Co. mined miscellaneous clay for heavy clay pducts. The State highway commission mined 7500 tons of paving sand.

Lenoir.—Barrus Construction Co. (Kinston mine) and the State highway commission mined 170,000 tons of sand and gravel for structural, paving, railroad-ballast, and fill purposes.

Lincoln.—Roe Woody (Brown mine) and Pat Buchanan (Miller mine) mined sheet mica. Fred Allen collected a small quantity of gem stones (amethysts). The State highway commission mined 37,000 tons of paving sand.

Macon.—Twenty-four mines produced sheet mica. The leading producers were Roy H. Fouts (Almond Cove and Rock Cut mines) and Harris Mining Co. (Harris mine). The leading producers of scrap mica were A & C Mining Co. (Sheppard Knob mine) and Charles E. Cook (Chalk Hill and Iotla mines). Macon Construction Co. and Hayes Block Co. mined structural sand and paving gravel. Fred Allen, Andrew W. Reid, and others collected a few gem stones (smarogdite-ruby and rhodalite garnets).

Martin.—The State highway commission mined 17,000 tons of paving sand.

McDowell.—Becker County Sand & Gravel Co. (Marion mine) mined sand and gravel for structural, paving, and railroad-ballast uses. The State highway commission (Woodlawn quarry) crushed limestone for concrete and roads.

Mecklenburg.—Superior Stone Co. Division (Charlotte and Pineville quarries) and the State highway commission crushed granite for concrete and roads. The State highway commission mined paving sand.

Mitchell.—Mitchell County ranked first in value of mineral production. Thirteen companies mined crude feldspar. The leading producers were International Minerals & Chemical Corp. (Hawkins and Kona mines), The Feldspar Corp. (Poteat, Wiseman, Sullins, Dogwood Flats, and Chestnut Flats mines), and Lawson-United Feldspar & Minerals Co. (Minpro mine). Sixty-four mines produced mica; 54 produced sheet only (full-trimmed and/or hand-cobbed), 3 scrap only, and 7 both sheet and scrap. The leading producers of sheet mica were Sink Hole Miners (Sink Hole mine), Mitchell Lumber Co. (Banner mine), and Abernathy Mining Co. (Abernathy, Abernathy No. 2, and Abernathy No. 3 mines). The leading producers of scrap mica were The Feldspar Corp. (Poteat and Wiseman mines), DeWeld Mica Co. (Sparks mine), and Southern Mica Co. of North Carolina, Inc. (Sullins mine).

International Minerals & Chemical Corp. and The Feldspar Corp. recovered crushed sandstone (quartz) from feldspar milling. J. J. Rogers, Jr., mined 25,000 tons of paving gravel. Herby Bolick, P. W. Holston, Ruth P. Stanley, Albert V. Topper, and Harley Hines collected various types of gem stones.

Montgomery.—Mt. Gilead Brick Co. mined miscellaneous clay for heavy clay products. T & H Clay Co., Inc. mined pyrophyllite for ceramics. The State highway commission (Candor mine) mined paving sand. Jacob's Creek Flagstone Co. (Edenboro quarry) quarried dimension slate for structural millstock and flagging.

Moore.—Standard Mineral Co., Inc., and Carolina Pyrophyllite Co., Inc., mined pyrophyllite for ceramics, insecticides, refractories, paint, roofing, rubber, and plaster. Five mines produced structural, paving, and fill sand. The leading producer was Pleasants Sand & Supply Co. T & H Clay Co. (Hancock mine) mined miscellaneous clay for heavy clay products. Harley Hines collected a small quantity of gem stones.

Nash.—O. H. Woolard and the State highway commission mined paving sand.

New Hanover.—E. B. Towles Construction Co. crushed stone for concrete and roads. Robbins Sand Pit and the State Highway commission mined sand for fertilizer filler and paving.

Northampton.—Superior Stone Co. Division (Garysburg mine) and the State highway commission mined sand and gravel for structural and paving uses.

Onslow.—Superior Stone Co. Division (Belgrade quarry) crushed limestone for concrete and roads. The State highway commission mined 5,000 tons of paving sand.

Orange.—Boren & Harvey (Hillsboro mine) mined pyrophyllite for refractories. Duke University quarried dimension stone for rough construction use. The State highway commission (Bacon quarry) crushed granite for concrete and roads.

Pamlico.—The State highway commission mined 8,000 tons of paving sand.

Pasquotank.—The State highway commission produced 3,000 tons of paving sand.

Pender.—The State highway commission mined 4,000 tons of paving sand.

Perquimans.—The State highway commission produced 10,000 tons of paving sand.

Person.—The State highway commission mined 13,000 tons of paving sand.

Pitt.—White Concrete Co. (Munford mine) and the State highway commission mined structural, paving, and fill sands.

Polk.—J. C. Williams (Williams quarry) quarried 240 tons of dimension granite for rough construction.

Randolph.—The State highway commission (Parks Cross Road and Glenola quarries) crushed 169,[illegible] tons of granite for concrete and roads. Superior Stone Co. Division crushed traprock for concrete and roads. Carolina Pyrophyllite Co., Inc. (Gerhardt mine) mined pyrophyllite for ceramic and insecticide uses. Herby Bolick and Harley Hines collected a small quantity of gem stones.

Richmond.—The State highway commission (Mc-Leod mine) mined 9,700 tons of paving gravel.

Robeson.—Southern Sand & Gravel Co. (Lumberton mine) and the State Highway commission mined paving and fill sand and gravel.

Rockingham.—Superior Stone Co. Division (Reidsville quarry) crushed granite for concrete and roads. Roanoke-Webster Brick Co., Inc. (Draper mine), mined miscellaneous clay for heavy clay products. Garland W. & Morris Hall (Kings quarry) crushed traprock for concrete and roads. The State highway commission mined paving sand.

Rowan.—Six quarries produced dimension granite for use as rubble, rough and dressed construction stone, dressed architectural stone, rough and dressed monumental stone, and curbing and flagging. The leading producer was Harris Granite Quarries Co. (Collins quarry). Superior Stone Co. Division (Woodleaf quarry) crushed granite for concrete and roads. Carolina Tufflite Co. and Isenhour Brick & Tile Co. (East Spencer mine) mined miscellaneous clay for lightweight aggregate and heavy clay products.

Gardner Granite Works produced millstones. Harris Granite Quarries Co. (Balfour quarry) produced tubemill liners and grinding pebbles. The State highway commission mined 41,000 tons of paving sand. Carolina Perlite Co., Inc., expanded perlite at its mill in Gold Hill.

Rutherford.—A. R. Thompson, contractor, mined paving gravel. Six mines produced full-trimmed mica and one sold a small tonnage of scrap mica. The leading mica producers was Mace & Son. R. D. Gross collected a small quantity of gem stones (corundum and fuchsite).

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Samson.—Crumpler Brick Co., Inc., Sampson Brick o., Inc., and Patterson Brick Co. mined miscellanous clay for heavy clay products. The State highway ommission mined 9,000 tons of paving sand.

Stanly.—Southern Lightweight Aggregate Corp. Aquadale mine), Stanly Shale Products, Inc. (Norood mine), and Yadkin Brick Yards, Inc., mined iscellaneous clay for heavy clay products and lighteight aggregates. The State highway commission rushed 55,000 tons of traprock for concrete and oads at the McManus quarry and mined 4,000 tons f paving sand. Carolina Aluminum Co. produced luminum metal at Badin.

Stokes.—Pine Hill Brick & Pipe Co. (No. 1 mine) ined miscellaneous clay for heavy clay products. he State highway commission mined 95,000 tons f paving sand. Six mines produced sheet mica. The ading producers were Snow Hill Mining Co. (Spenr mine) and Lemmie and Curtis Mabe (Mabe ine).

Surry.—North Carolina Granite Corp. quarried imension granite for rough and dressed construction one, rough and dressed architectural stone, dressed onumental stone, and curbing and flagging. North arolina Granite Corp. (Mount Airy quarry) and rarat Products Co. produced granite for riprap, ncrete, roads, poultry grit, and other uses. The ate highway commission mined paving sand and ravel. Ruth P. Stanley collected a small quantity gem stones. (citrine quartz).

Swain.—The Feldspar Corp. (Alexander mine) ined crude feldspar. Nantahala Talc & Limestone o. (Hewitt quarry) crushed limestone for concrete, ads, and agstone.

Transylvania.—Seniard Brothers, Kermit Reese untry Club, Inc., and Coleman Scott mined strucral sand and paving gravel. Macon Construction ., Inc., quarried dimension granite for rubble and ushed granite for concrete and roads. James E. ore (Fred Hall mine) and Jeter C. Kitchen (Toxay mine) mined small quantities of sheet mica. whatan Mining Co. (Kilpatrick mine) mined asstos. E. I. du Pont de Nemours & Co., Inc., proced high-purity silicon at Brevard.

Union.—Superior Stone Co. Division (Bakers arry) and the State highway commission crushed prock for concrete and roads. Kendrick Brick & e Co. (Monroe mine) mined miscellaneous clay f heavy clay products.

Vance.—W. E. Graham & Sons Division (Greystone quarry) produced granite for riprap, concrete, roads, and railroad ballast. Tungsten Mining Corp. (Hamme mine) shipped tungsten concentrate from stock. The State highway commission mined paving sand.

Wake.—Superior Stone Co. Division (Crabtree and Rolesville quarries) and Nello L. Teer Co. (Raleigh quarry) produced granite for riprap, concrete, roads, railroad ballast, and other uses. The State highway commission mined paving sand. Harley Hines collected a small quantity of gem stones (actinolite).

Washington.—The State highway commission mined 48,000 tons of paving sand.

Watauga.—The State highway commission mined 11,000 tons of paving gravel.

Wayne.—Nello L. Teer Co., Superior Stone Co. Division (Goldsboro mine), and the State highway commission mined structural and paving sand and miscellaneous gravel.

Wilkes.—Stone Mining Co. crushed granite for concrete and roads. The State highway commission mined paving sand. Tracy Higgins (Tracy mine), mined sheet and scrap mica and C. W. Ellis (Hoilman mine), and Mrs. R. C. Jennings (Elk Creek mine) mined sheet mica only. Blue Ridge Minerals Co. and Albert V. Topper collected various types of gem stones.

Wilson.—Superior Stone Co. Division (Neverson and Elm City quarries) crushed granite for concrete and roads. Five mines produced structural, paving, and fill sand. The leading producers were the State highway commission and Gray Concrete Pipe Co., Inc.

Yadkin.—Stone Mining Co. (Cycle quarry) crushed granite for concrete and roads. The State highway commission mined 16,000 tons of paving sand.

Yancey.—Thirty-six mines produced mica; 30 produced sheet only (full-trimmed and/or hand-cobbed), 5 scrap only, and 1 both sheet and scrap. The leading producers of sheet mica were Geouge & Allen (Barger mine) and Eugene and V. O. Adkins (Coletta mine). The leading producers of scrap mica were Deneen Mica Co. (Young Mica mine) and Hassett Mining Co. (Simpson mine).

The Feldspar Corp. (Webb, McCracken, Land's Creek, and McClain mines) mined crude feldspar. McCrary Construction Service Co. mined paving gravel. C. R. Wiseman (Wray mine) mined olivine. Herby Bolick and Floyd Wilson collected various types of gem stones.

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DIVISION OF MINERAL RESOURCES
STEPHEN G. CONRAD, *State Geologist*

Economic Paper 68

DEC 20 1976

Mineral Industry of North Carolina From 1960 Through 1967

BY

JASPER L. STUCKEY

RALEIGH

1970

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Letter of Transmittal

Raleigh, North Carolina
March 31, 1970

To His Excellency, Honorable Robert W. Scott
Governor of North Carolina

Sir:

I have the honor to present herewith manuscript for publication as Economic Paper 68, "Mineral Industry of North Carolina From 1960 Through 1967," by Jasper L. Stuckey.

This report contains a summary and review of the mineral industry of the state for the period 1960-1967. During this period, the tonnage and value of minerals produced reached the highest value recorded during any previous period in the state's history. The initial production of cement and phosphate during this period were significant contributions to the mineral commodities produced in North Carolina.

The demand for all varieties of mineral products increases each year. The information contained in this report should be of value to mineral producers, manufacturers and others interested in the minerals found in North Carolina.

Respectfully submitted,

Roy G. Sowers, Jr.
Director

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MINERAL INDUSTRY OF NORTH CAROLINA FROM 1960 THROUGH 1967

By

JASPER L. STUCKEY

ABSTRACT

During the period 1960-1967, the mineral industry of North Carolina continued to grow and reached an all time high in both tonnage and value. The average annual value of the state's mineral production was $57,494,678 and the average tonnage was 33,135,125 tons. This represents an increase of 70.2 percent n value and 64.12 percent in tonnage over the previously reported period 1954-1959.

Both metallic and nonmetallic minerals are produced but nonmetallic minerals and rocks dominated production and accounted for more than 80 percent of the average annual value of the minerals produced during the years 1960, 1961, 1962 and 1963. During he last half of the period (1964, 1965, 1966 and 1967), nonmetallic minerals accounted for 100 percent of production as metals were not produced during those years. It is interesting to note that each of the years 1964, 1965, 1966 and 1967 successively set a new all time high record for both onnage and value of mineral production in North Carolina. No mineral fuels were produced during he period 1960-1967.

In the order of decreasing value, stone, sand and gravel, phosphate rock, feldspar, lithium minerals, mica, clays and shales and talc and pyrophyllite are he minerals that have been most commonly produced n North Carolina in recent years. In 1967, stone production was dominant and accounted for 53 percent of the state's total.

North Carolina ranked first among the states in he production of feldspar, mica and lithium minerals, second in olivine and fourth in talc and pyrophyllite combined in 1967.

INTRODUCTION

The potential mineral wealth of North Carolina s much greater than is generally recognized. More han 300 varieties of minerals and rocks have been dentified in the state which is reported to be the reatest number found in any state. North Carolina contains deposits of metallic minerals, nonmetallic minerals and rocks and mineral fuels, but is best known as a producer of nonmetallic minerals. During the period 1960-1967, some metallic minerals were produced in the years 1960, 1961, 1962 and 1963. Nonmetallic minerals were produced each year of the period, but no mineral fuels were mined. In the order of decreasing value, stone, sand and gravel, phosphate rock, feldspar, lithium minerals, mica, clays and shales and talc and pyrophyllite are the minerals that have been most commonly produced for several years.

In 1967, the mineral industry of North Carolina continued to grow and contributed $77,094,519 to the state's economy which was an increase of about $5,000,000 or 7.00 percent over that of 1966. The mineral production of 1967 set a new record for the fourth consecutive year. The production of stone was dominant and contributed 53 percent of the total value. Leading mineral producers were Superior Stone Company, Ideal Cement Company, Vulcan Materials Company and Texas Gulf Sulphur Company.

North Carolina ranked first among the states in the production of feldspar, mica and lithium minerals, second in olivine and fourth in talc and pyrophyllite.

ACKNOWLEDGEMENTS

This report is based largely upon production figures and other data on the mineral industry of North Carolina which were collected by the United States Bureau of Mines in cooperation with the Division of Mineral Resources. Much of the information thus collected is published annually in the Minerals Yearbook of the United States Bureau of Mines. Other sources of information include reports of the United States Geological Survey, the North Carolina State University Minerals Research Laboratory, various articles in technical publications and from the files and published reports of the North Carolina Department of Conservation and Development.

STATISTICAL REVIEW

Table 1 summarizes the mineral production of North Carolina by items and years for the period 1960-1967. The value of minerals produced in the state varied from $45,097,209 in 1960 to a new high of $54,648,373 in 1962, from which it declined to $44,882,092 in 1963, and then increased yearly to an all time high of $77,094,519 in 1967. The average annual value of the minerals produced in North Carolina was $57,494,678 for each year of the period, which was the greatest ever recorded for any eight year period. The tonnage of miner produced in the state during the same period rang from 27,041,000 tons in 1960 to 36,286,000 in 19 from which it declined to 30,706,000 in 1963 increased yearly to a new all time high of 37,908,0 tons in 1967. The average annual production w 33,135,000 tons for each year of the period whi was the greatest tonnage production ever record in any eight year period. This demonstrates that t mineral industry of North Carolina is growi rather than showing an increase in value due rising prices.

Table I. Mineral Production in North Carolina, 1960-1967—Mine Value

	1960	1961	1962	1963	1964	1965	1966	196
Abrasive stone	2,000	3,000	2,000	2,000	(2)	(2)	(2)	
Asbestos	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Barite	(2)	(1)	(2)	(2)	(2)	(2)	(2)	6,
Cement, portland & masonary	(2)	(2)	(2)	(1)	(1)	(1)	(1)	
Clays and shales	1,547,680	1,668,915	1,782,305	1,761,100	2,064,087	2,161,882	2,241,000	2,012,
Copper	(1)	(1)	(1)	(2)	(2)	(2)	(2)	
Feldspar	2,781,000	2,476,712	2,373,000	2,821,000	2,342,000	3,152,923	3,157,156	3,113,
Gem Stones	4,326	5,885	2,375	14,484	15,000	15,000	15,000	25,
Gold	64,000	73,290	16,200	1,155	(2)	(2)	(2)	
Iron Ore	(1)	1,292	13,080	9,816	(2)	(2)	(2)	
Kaolin	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Lead	99,216	65,508	40,296	13,000	(2)	(2)	(2)	
Lithium	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Mica: scrap and flake	1,099,502	1,010,389	1,384,280	1,497,345	2,026,682	1,986,970	2,348,369	1,751,
Mica: sheet	1,539,440	2,237,034	866,631	12,604	58,481	184,656	1,000	
Olivine	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Phosphate rock	(2)	(2)	(2)	(2)	41,000	(2)	(1)	
Sand and gravel	7,453,304	8,467,224	11,457,283	10,132,000	10,404,000	10,076,000	11,132,000	9,962,
Silver	192,203	157,625	108,976	34,222	(2)	(2)	(2)	
Stone: granite, etc.	19,808,769	22,127,000	25,895,562	21,971,431	25,560,157	25,375,216	29,760,309	34,961,
Stone: limestone, etc.	3,487,231	3,135,000	3,687,438	3,711,569	5,073,243	5,997,814	6,826,471	6,526,
Talc and pyrophyllite	549,282	367,040	432,947	446,376	495,146	556,352	576,050	512,
Zinc	(2)	(2)	(2)	2,990	(2)	(2)	(2)	
Tungsten	(1)	(1)	(1)	(1)	(2)	(2)	(2)	
Undistributed*	6,469,256	8,329,000	6,586,000	2,464,000	7,648,000	10,855,970	15,821,220	18,225,
	45,097,209	50,124,914	54,648,373	44,882,092	55,727,796	60,362,783	71,878,575	77,094,

* Undistributed includes copper, gold, lithium, silver, tungsten, zinc, asbestos, cement, kaolin, phosphate rock and barite.
1. Figures withheld to avoid disclosing individual company confidential information.
2. No production reported.

Growth is further emphasized by pointing out that, as shown in Economic Paper 67, the value of minerals produced in the period 1954-1959 varied from $41,651,000 in 1954 to $40,789,423 in 1959 and averaged $40,346,000 for each year of the period while tonnage production varied from 20,439,000 tons in 1954 to 24,388,000 tons in 1959 and averaged 21,168,548 tons for each year of the period. This is an increase in average annual value of $17,148,679 and an increase in the average annual tonnage of 11,966,827 tons during the period 1960-1967 over the period 1954-1959.

The relative value of the minerals produced North Carolina during the period 1960-1967 is sho in Figure 1 which gives the average annual va of the various minerals produced during the peri Nonmetallic minerals and rocks dominated prod tion and accounted for more than 80 percent of average annual value of the minerals produced d ing the years 1960, 1961, 1962 and 1963. During last half of the period (1964, 1965, 1966 and 196 nonmetallic minerals and rocks accounted for 1 percent of production as no metals were produc during these years.

COMMODITY	VALUE
GRANITE	25,684,938
SAND AND GRAVEL	9,885,476
UNDISTRIBUTED	9,676,038
LIMESTONE AND MARBLE	4,799,463
FELDSPAR	2,777,110
MICA	2,275,697
CLAY AND SHALE	1,904,871
TALC AND PYROPHYLLITE	491, 085

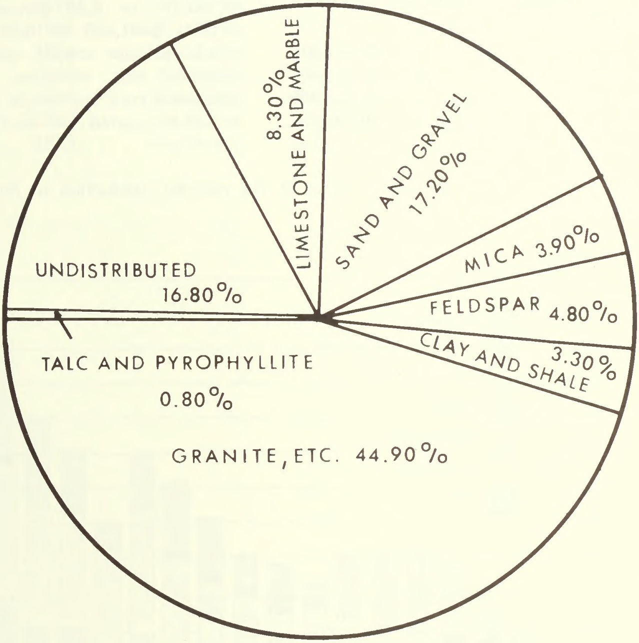

FIGURE 1. AVERAGE ANNUAL VALUE OF MINERAL PRODUCTION BY COMMODITY IN N. C. 1960 — 1967

Table 2. Average Annual Value of Mineral Production by Items 1960-1967

Clays and shales	$ 1,904,871
Feldspar	2,777,110
Mica	2,275,697
Sand and gravel	9,885,476
Granite, etc.	25,684,938
Limestone, etc.	4,799,463
Talc and pyrophyllite	491,085
Undistributed	9,676,038
Average annual value of all minerals produced 1960-1967	$57,494,678

Table 3. Annual Tonnage of Minerals Produced 1960-1967

1960	27,041,000
1961	29,354,000
1962	36,286,000
1963	30,706,000
1964	32,792,000
1965	33,177,000
1966	37,817,000
1967	37,908,000
Average annual tonnage of minerals produced 1960-1967	33,135,125

Clays and shales, exclusive of kaolin, accounted for $1,904,871 or 3.30 percent of the average annual production; feldspar accounted for $2,777,110 or 4.80 percent; mica $2,275,697 or 3.90 percent; sand and gravel $9,885,476 or 17.20 percent; granite, etc., $25,684,938 or 44.90 percent; limestone and marble $4,799,463 or 8.30 percent; and talc and pyrophyllite $491,085 or 0.80 percent. Undistributed which includes copper, gold, lead, lithium, silver, tungsten, zinc, asbestos, cement, kaolin, olivine, phosphate rock and minor minerals, barite and gem stones accounted for $9,676,038 or 16.80 percent.

Figure 2 shows graphically the growth in value of the mineral production of North Carolina for the 18 year period 1950-1967.

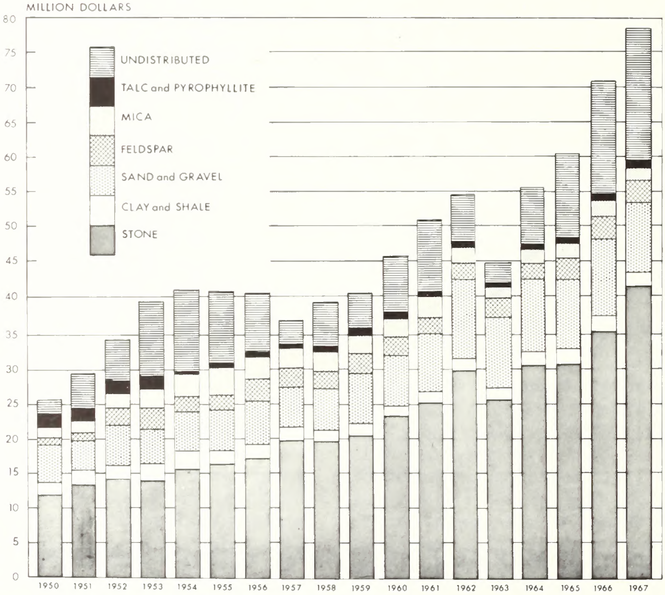

FIGURE 2. Total value of mineral production in North Carolina, 1950—1967. Undistributed values include abrasive stones, asbestos, barite, cement, copper (1954—1962), gem stones, gold (1954—1963), iron ore (1961—1963), kaolin, lead (1954—1963), lithium, olivine, phosphate, tungsten (1954—1963).

Table 4 below shows the annual value of the minerals produced in North Carolina from 1900 through 1967.

Table 4. Annual Value of Minerals Produced in North Carolina from 1900 through 1967.

Year	Total Value
1900	1,604,078
1901	1,799,109
1902	2,003,077
1903	1,902,485
1904	1,985,675
1905	2,439,381
1906	3,007,601
1907	3,173,722
1908	2,303,116
1909	2,873,826
1910	2,848,446
1911	2,933,878
1912	3,514,892
1913	3,879,340
1914	3,692,461
1915	3,584,725
1916	4,746,674
1917	5,411,452
1918	5,192,047
1919	6,404,679
1920	8,117,916
1921	5,676,301
1922	7,483,305
1923	11,050,257
1924	10,163,437
1925	10,699,422
1926	11,274,224
1927	12,566,822
1928	12,355,934
1929	14,668,817
1930	10,086,459
1931	7,581,384
1932	3,794,999
1933	5,243,158
1934	6,754,471
1935	7,502,567
1936	9,955,519
1937	13,049,056
1938	14,959,228
1939	18,533,720
1940	21,112,732
1941	18,915,461
1942	17,372,696
1943	22,172,000
1944	22,199,000
1945	14,457,000
1946	14,947,238
1947	16,385,272
1948	18,231,000
1949	19,755,000
1950	26,343,000
1951	29,646,000
1952	34,730,943
1953	38,458,350
1954	41,651,000
1955	41,219,001
1956	40,870,150
1957	37,664,260
1958	39,891,409
1959	40,789,423
1960	45,096,209
1961	50,124,913
1962	54,598,373
1963	44,895,576
1964	55,727,796
1965	60,382,777
1966	71,878,775
1967	77,094,519

MINERAL RESOURCES

As previously stated, North Carolina contains approximately 300 varieties of minerals and rocks. Some of these are not abundant and are of interest chiefly to collectors. Others occur widespread about the state but are not concentrated in sufficient amounts to be of economic importance. Approximately seventy varieties of minerals and rocks that have commercial value are known to occur in the state and some thirty to forty of these have been produced during the present century. The minerals of commercial value that have been produced, explored for or have made economic contributions to the economy of the state during the period 1960-1967, are described below under three classes, namely, metallic minerals, nonmetallic minerals and rocks and mineral fuels. It is not always possible to draw a perfect line between metallic and nonmetallic minerals, but this classification has much to recommend it and is used here.

METALLIC MINERALS

North Carolina is not and never has been an important producer of metallic minerals. It does, however, contain varying amounts of several metals, some of which have been successfully produced. During the period of this report, there was some interest or activity in metallic minerals in the state as indicated below. However, no metals were produced from minerals mined in North Carolina during 1964, 1965, 1966 and 1967.

Aluminum

Commercial deposits of aluminum ore are not known to occur in North Carolina. However, the Aluminum Company of America has operated, at Baden, North Carolina, for a number of years a smelter for the production of metallic aluminum. This smelter is located at Baden on the Yadkin River in Stanly County because of the availability of electric power there. It operates on imported ore. This smelter, which according to the 1959 Minerals Yearbook of the United States Bureau of Mines, had a primary aluminum production capacity of 47,150 tons per year, was replaced in 1964 by a new pot line with a capacity of 52,000 tons annually. In 1967, a second 50,000 ton per year pot line was put into operation at this smelter. This was made possible by the completion in 1962 of the Tuckertown
droelectric development which added 150 mill
kilowatt hours annually to the available supply
electric power at Badin.

Beryllium

Small amounts of the mineral beryl, the ch
source of beryllium, are associated with pegmat
dikes which are widely distributed through the Pi
mont and Mountain sections of the state. The p
duction of beryl is sporadic and is usually obtai
as a byproduct of feldspar and mica mining. T
greatest concentration of beryl in North Carol
is in the tin-spodumene belt of the Kings Mount
district. According to Griffitts (1954) "Berylli
Resources of the Tin-Spodumene Belt, North Ca
lina," in U.S. Geological Survey Circular 309,
belt contains 823,000 tons of beryl equivalent
122,800 tons of Be0. These figures are based o
Be0 content of 0.05 percent in the pegmatites
the tin-spondumene belt. If a process for conc
trating the beryl present in these pegmatites
be developed, North Carolina should become an
portant producer of beryllium ore. The United Sta
Bureau of Mines has done considerable work on
problem but no results are available.

Copper

Copper deposits in North Carolina occur in th
zones which conform to the regional trend of
country rocks and generally extend in a northea
southwest direction. These three zones are
Western Zone, the Central Zone and the East
Zone. The Western Zone is the most important
the three and lies west of the Blue Ridge Mountai
It persists in general across the western part
the state and extends into Virginia, Tennessee
Georgia. The Central Zone is confined largely
the granitic crystalline rocks of the Carolina Igne
Belt. The Eastern Zone lies entirely within
Carolina Slate Belt along the eastern part of
Piedmont plateau.

Copper production, which has been intermitt
since the early 1850's in North Carolina was
sumed in 1954 with a small production from
H and H mine located near Glenview, Hali
County, about eight miles southwest of Enfield

small production was made at this mine in 1954, 1955 and 1956 but no activity at this mine has been reported since 1956.

In 1954, Appalachian Sulphides, Inc., took title to the old Ore Knob mine in Ashe County and during the next three years carried out exploration work, opened and equipped a mine and constructed a concentrating plant. The initial ore reserves were indicated to be 1,330,300 tons which contained 3.0 percent copper and 14.0 percent sulphur.

The Ore Knob vein is a steeply dipping (70°) tabular body that strikes, N. 64° E. and has a plunge of 20° to the southwest. It is believed to be a mineralized fault and consists of brecciated fragments of wall rock surrounded and replaced by sulphides. Two main types of mineralization have been recognized: massive pyrrhotite-pyrite-chalcopyrite that contains sealed fragments of wall rock; and disseminated to massive granular pyrite with a ittle chalcopyrite and pyrrhotite. The country rock s a "Carolina" type quartz-mica gneiss which makes sharp and well-defined contacts with the ore body.

Production from this mine started in February 957 and continued into December 1962 when the re reserves were depleted and the mine abandoned.

During the years 1960, 1961, 1962 and 1963, copper was recovered by flotation of accumulated tailings at the tungsten mill of Tungsten Mining Corporation near Townville, Vance County.

Gold and Silver

The first discovery of gold in North Carolina was made in 1799 and systematic mining began about 803. From 1804 through 1828, North Carolina furnished all the gold mined in the United States. It ontinued to be the leading producer of gold until bout 1850 when California took the lead. Since that me, gold production in North Carolina has been termittent.

The areas that have produced gold in North Carona are usually grouped into six belts as follows: 1) Eastern Carolina Belt; (2) Carolina Slate Belt; 3) Carolina Igneous Belt; (4) Kings Mountain elt; (5) South Mountain Belt and (6) Western elt. Within these six belts and adjoining areas here are more than 40 counties that contain approximately 660 old gold mines and prospects, none of which are being worked at the present time.

Prospecting and development work which was started at the Star mine about 1954 or 1955 was renewed about 1959 and several drill holes were put down upon the property. Later a two compartment shaft was started into the property at an angle of 45°. A new 100 ton per day capacity cyanide plant was constructed at the Candor mine near Waxhaw, Union County for processing the ore. All indications late in 1960 pointed to a successful gold mining venture. The mine known as the Star mine is located about four miles southwest of Star in Montgomery County. Operations were being conducted under the name Union Refining and Mining Company. A small production of gold and silver was reported from this mine in 1963.

The production of gold in North Carolina from 1799 through 1963 was 1,173,514 fine ounces valued at $24,639,108 according to the best conservative estimates and records available. During the period 1960 through 1967, production amounted to 4,413 fine ounces valued at $94,845. This gold was recovered from the smelting of concentrates from Ore Knob Mine of Appalachian Sulphides, Inc., in Ashe County and tailings from the tungsten mill of Tungsten Mining Corporation in Vance County, except 25 fine ounces valued at $875 in 1963 which came from the mine of Union Refining and Mining Company in Montgomery County.

Silver is commonly classed and discussed with gold. In addition to its occurrence with gold ores, silver is probably more commonly and abundantly associated with ores of copper, lead and zinc. The total production of silver in North Carolina from 1799 through 1963 is recorded as 959,220 fine ounces of which some 850,000 ounces came as a byproduct of copper, lead and zinc mining. During the years 1960-1963 (no production was reported in 1964-1967), the production of silver in North Carolina amounted to 509,303 fine ounces valued at $492,000 all of which came as a byproduct of copper and tungsten mining except 23 fine ounces valued at $30 which came from the Star mine of Union Refining and Mining Company in 1963. The banner year was 1960 when 212,368 fine ounces valued at $192,000 were produced.

Iron

The first discovery of iron ore in the United States was made in 1585 in what is now North Carolina by members of an expedition that Sir Walter Raleigh sent out to establish a colony on Roanoke Island. Iron ore was reported at two places, one about fourscore and the other about sixscore miles from the fort. These places appear to have been on the Roanoke River near Weldon and Gaston. The first production of iron in North Carolina was made in 1728-1729 when small amounts of pig iron were shipped to England.

Iron ores are widely scattered over North Carolina, but the deposits are small and generally low grade. Bog limonite occurs in a number of counties in the Coastal Plain while deposits of limonite, hematite and magnetite are widely distributed throughout the Piedmont and Mountain sections of the state.

A modest iron mining and processing industry was established about the beginning of the American Revolution and continued intermittently and with varied success until about 1930. The main production of iron in North Carolina was made during the period 1900-1930 inclusive, when according to available figures 1,529,973 tons of iron ore were produced. The banner year was 1918 when 108,332 tons were produced.

During the first three years of this period of major production, small amounts of iron were produced in Chatham, Gaston and Johnston counties, but the major production came from west of the Blue Ridge Mountains. Cherokee and Madison counties produced limonite while Ashe and Avery counties produced magnetite.

In 1959, Cranberry Magnetite Corporation secured a 20 year lease on the Cranberry mine, which had been operated with some success between 1882 and 1930, and began plans for reopening the mine. A small production of magnetite iron ore was made in 1960, 1961, 1962 and 1963.

Lead and Zinc

There are no lead or zinc mines in North Carolina. Small amounts of lead and zinc have been produced in North Carolina over the years since about 1840. all of which came from mines that produced more or less complex ores of gold, copper, lead, zinc and silver.

Mines and prospects that have been worked primarily for lead, zinc or silver in North Carolina include the Silver Hill mine, the Silver Valley mine, the Redmon prospect, the Little Hungry River prospect and the House mine.

It appears from the records, that the first production of lead and zinc in North Carolina was made at the Silver Hill mine. This mine, for a long time known as the Washington mine was discovered, according to the best available records, in 1838. Elisha Mitchell (1842 Elements of geology with an outline of the geology of North Carolina) stated that " . . . . . the owner (Byerly) of a small tract was led to examine a spot at the top of a hill in the hope of finding gold. He found the carbonate of lead and then sold his possessions.

Mr. Roswell King, who became the purchaser sunk a shaft and fell in with the ores of the other metals, silver, copper, zinc, during the summer that year, and in the following winter the Washi ton Mining Company was incorporated."

This mine was operated intermittently until 18 when it was closed and allowed to fill with wat In 1898 the mine was reopened and kept open un 1900 during which time a small amount of argen ferous galena and sphalerite were shipped.

In 1942, the New Jersey Zinc Company explor the property by 19 core holes. No valuable ore w found and the project was discontinued.

In 1958-1959, the Tennessee Copper Compa carried out extensive drilling at the Silver Hill m which revealed the presence of rich lead and z ore at depths of approximately 1500 feet. In 19 work was started on clearing out and deepening old inclined shaft to a length of more than 1700 f to reach the ore. The ore found was rich in val but the deposit was too small to work economica and the mine was abandoned in 1960 and allowed fill with water.

Lead in 1960, 1961, 1962 and lead and zinc 1963 were produced from the accumulated taili at Tungsten Mining Corporation's operations Vance County.

Titanium

Titanium minerals of some interest are known occur at three localities in the state. These a (1) lenses of granular ilmenite dissemina throughout talcose bodies which lie conforma with the enclosing mica gneiss and schist near Fi ley, north of Lenoir in Caldwell County; (2) pla rutile in the Elf-Shooting Creek area of Clay Cou and (3) ilmenite sands in the Coastal Plain regi especially in Beaufort, Gates, Chowan and Per mans counties.

Yadkin Valley Ilmenite Company, a subsidiary the Glidden Company, carried out mining in Finley area of Caldwell County between 1942 1952 but discontinued mining in October 1952 beca most of the readily processed ore had been wor out. American Smelting and Refining Company p spected the Clay County rutile deposits in 1955 failed to start production because the available t nage of rutile was too small for American Smelt and Refining Company's needs.

Several companies have prospected various menite areas in the Coastal Plains. The last s investigation was completed about 1959. No min has been carried out in that area.

The only activity in titanium in North Carol during the period under consideration was an nouncement in the United States Bureau of Mi

Minerals Yearbook for 1967 that Teledyne, Inc., had formed a new company, Teledyne Titanium, to concentrate on the development, manufacture and sale of titanium base alloys. Alloy bars are to be produced in a new plant at Monroe, North Carolina. The source of raw materials was not indicated.

Tungsten

Tungsten minerals are known to occur in two localities in North Carolina. One of these is in Cabarrus County and the other is in the northern part of Vance County.

Small amounts of scheelite have been found at several old gold and copper mines in Cabarrus County. Among these are the California, Phoenix, Furniss, Flowe, Cline and Crosby. Between 1948 and 1950, the United States Bureau of Mines did drilling at the Cline and Furness mines but no production was made. In 1954, Carolina Tungsten Mining Company was formed and with the aid of DMEA carried out further exploration at the Phoenix, Cline and Furness mines. Commercial deposits of tungsten minerals were not found and attempts at mining were discontinued.

In 1942, Joseph and Richard Hamme discovered tungsten ore about 2.5 miles west of Townsville in the northwestern part of Vance County. The deposits consists of mineralized quartz veins that lie in a pronounced zone of fracture near the contact between granite and volcanic rocks of the Carolina Slate Belt. Huebnerite and scheelite are the chief tungsten minerals. They are associated with varying amounts of sphalerite, pyrite, chalcopyrite, galena, tetrahedrite, rhodochrosite and fluorite. These gangue minerals have yielded important amounts of gold, silver, copper and lead.

The Hamme brothers prospected and mined the veins on a small scale until August 1943 when Haile Mines, Inc., acquired the property. In June 1945, Tungsten Mining Corporation, a new company formed by Haile Mines, Inc. and General Electric Company, took over the property. The property was developed rapidly between 1947 and 1951. Between 1951 and June 30, 1958, this property was the largest single producer of tungsten concentrates in the United States. The mine and mill were closed on June 30, 1958 due to market conditions.

Operations were resumed at this mine and mill on June 1, 1960 and continued until the end of February 1963 when the mine and mill were again closed due to market conditions.

Recently, interest in this property, which is reported to contain proven and probable reserves of 1 million tons of tungsten oxide ore, has been renewed and in 1967 Ranchers Exploration and Development Corporation of Albequerque, New Mexico, obtained an option to purchase the property.

NONMETALLIC MINERALS AND ROCKS

The chief mineral resources of North Carolina consist of nonmetallic minerals and rocks. These materials accounted for 80 percent of the value of the state's mineral production during the years 1960, 1961, 1962 and 1963 and 100 percent of the value during the years 1964, 1965, 1966 and 1967.

In the order of decreasing value, stone, sand and gravel, phosphate rock, feldspar, lithium minerals, mica, clays and shales and talc and pyrophyllite are currently the nonmetallic materials most commonly produced in North Carolina.

Abrasive Stones

Natural abrasives found in North Carolina include corundum, emery, garnet, quartz, quartzite and granitic rocks. In recent years, manufactured abrasives have to a large extent replaced natural abrasives. As a result, the only native material used for abrasives in North Carolina since 1944 was granite. From 1954 through 1963, Gardner Granite works produced millstones from granite in Rowan County. No natural abrasives have been produced in North Carolina since 1963.

Asbestos

Asbestos is associated with basic igneous rocks, commonly known as peridotites, at a number of localities in the western Piedmont and Mountain regions of North Carolina. Anthophyllite, the amphibole variety, is the most common, but chrysotile, the serpentine variety is known to occur in several places. In general, the individual deposits are small but where several deposits are located in the same vicinity the asbestos has been mined successfully.

Although the annual production of asbestos from North Carolina has been comparatively small and at times irregular, the state has been a producer for more than 50 years. Over the years, considerable tonnages have been mined from Macon, Jackson, Transylvania, Avery, Mitchell and Yancey counties. During the period covered by this report, amphibole asbestos was produced in two counties. Production was reported from Yancey County each year of the period and from Transylvania County only for the year 1960. The Powhatan Mining Company, Woodlawn, Baltimore, Maryland, was the only producer during the period 1960-1967. The crude asbestos was shipped to Baltimore, Maryland by truck where it was processed for use.

Barite

Barite occurs at a number of localities in North Carolina, three of which have been prospected and/or mined for barite. These are (1) the Latta prospect approximately 3.5 miles southeast of Hillsborough, Orange County, (2) the Kings Mountain area in Cleveland and Gaston counties, and (3) the Hot Springs area of Madison County.

At the Latta prospect, the barite occurs in a sheared volcanic tuff of Ordovician (?) age. Small barite veins or lenses, some of which are associated with quartz veins or lenses, apparently conform with the local rock cleavage which strikes N. 20° E. and dips steeply to the northwest. Some prospecting but no mining has been done here.

In the Kings Mountain area, barite occurs in a narrow but irregular belt that extends from Crowders Mountain in Gaston County, North Carolina southwest to Gaffney, South Carolina. The barite is associated almost entirely with a white, siliceous sericite schist. The barite deposits consist of stringers and lenticular masses from less than an inch to more than 2 feet in thickness which, in general, parallel the schistosity of the enclosing rock. Five properties have been prospected and mined to a limited extent, but no production was made during the period 1960-1967.

In the Hot Springs area, the principal rocks are granites of Precambrian age and feldspathic quartzites of Cambrian age. Barite occurs in both rocks. The principal barite deposits are localized along thrust faults or in fractured rocks adjacent to these. The barite occurs in veins and as pods and stringers.

From 1884 until about 1927, barite was mined intermittently and a number of mines—the Stackhouse, Marshburn, Betts and Gahagan—produced considerable barite. The greatest production was made during the period 1904-1916, most of which came from the Stackhouse, Betts and Gahagan mines.

Barite production in North Carolina has been practically nil since 1927. During the year 1961, Bex-Tex, Inc., mined a small quantity of barite from the Stackhouse mine and in the 1967 Fluid Power Pump Company mined a small amount near Stackhouse in Madison County.

Cement

North Carolina became a producer of cement in 1963 when Ideal Cement Company put into operation a modern cement plant at Castle Hayne, New Hanover County. This plant which was constructed at a cost of some $20 million has a capacity of 3 million barrels annually.

This plant is a result of interest and activity o the part of the State of North Carolina. The North Carolina General Assembly of 1949 passed an a authorizing the appointment of a commission investigate the possibility of establishing a portlan cement plant in the state. This commission recom mented that a study of available raw materials fo cement manufacture in the state be made.

A study project was started in January 1950 un der the joint sponsorship of the Department o Conservation and Development, the Highway an Public Works Commission and the Department o Agriculture and was completed in June 1951. This survey established the presence of large reserves o high-grade limestone in the Castle Hayne limestone formation in the Coastal Plain.

Following the investigation by the State of North Carolina, the Volunteer Portland Cement Company of Knoxville, Tennessee, carried out additional ex ploration and acquired considerable limestone in the vicinity of Maple Hill. Plans were underway to con struct a plant with a capacity of 1.5 million barre per year when Volunteer Portland Cement Company became a wholly owned subsidiary of Ideal Cement Company of Denver, Colorado, in late 1959.

In 1960, the Ideal Cement Company announced plans to build a modern cement plant near Cast Hayne, north of Wilmington in New Hanover County. The plant was dedicated on July 6, 1962 when storage, packing and bulk shipping faciliti were completed. In 1963, the Ideal Cement Company began the operation of a highly instrumented ce ment plant at Castle Hayne with an annual capacity of 3.5 million barrels of cement. Raw materials used in manufacturing are limestone, clays, gypsum and pyrite cinders. The limestone and most of the clay are obtained locally—the limestone from the Cast Hayne limestone formation and most of the clay from the overburden on the limestone. The gypsum and pyrite cinders are imported.

As there is only one producer of cement in the state, production figures cannot be made public.

Clays, Shales and Kaolin

North Carolina is a leading producer of clays, the principal types being (1) common clays and shal suitable for the manufacture of brick and tile, sewer pipe, lightweight aggregate and other structur clay products; and (2) minerals of the kaolin group which constitute high-grade china clays or kaoli The first type is common throughout most of the state, but the second is restricted in occurrence.

The more important resources of commercial clays are: (1) the weathered slates of the Carolina Slate belt, especially those in Davidson, Stanly, Montgomery, Anson and Union counities; (2) the Rome shales near Hot Springs, Madison County; (3) weathered portions of the Brevard schist in Henderson County; (4) Triassic shales in Stokes and Rockingham counties; and (5) Triassic shales in Durham, Lee, Chatham, Moore and Anson counties. With the exception of the Hot Springs area, the deposits in other areas listed have been developed extensively.

In 1967, there were 27 companies in the state that mined clays and shales in 21 counties for use in the manufacture of brick and tile, vitrified sewer pipe, lightweight aggregate and other clay products.

Table 5. Principal Producers of Clays and Shales in North Carolina, 1967

Company	Mine	County
Hanford Brick Company, Inc.	Hanford	Alamance
Statesville Brick Company	Statesville	Catawba
Pomona Pipe Products Company	Gulf	Chatham
Sanford Brick Corporation	Gulf	Chatham
Boren Clay Products Company	Gulf	Chatham
Ideal Brick Company, Inc.	Thomasville	Davidson
Boren Brick & Tile Company	Durham	Durham
Triangle Brick Company	Durham	Durham
Boren Clay Products Company	Pleasant Garden	Guilford
Nash Brick Company	Ita	Halifax
Carolina Lightweight Aggregate	Harnett	Harnett
Moland-Drysdale Corporation	Fletcher	Henderson
Crumpler Brick and Tile Company	Smithfield	Johnston
Lee Brick and Tile Company	Sanford	Lee
Sanford Brick Corporation	Colon	Lee
Borden Brick and Tile Company	Sanford	Lee
Hanford Brick Company	Colon	Lee
Montgomery Shale Products Co.	Mt. Gilead	Montgomery
Taylor Clay Products Company	Salisbury	Montgomery
Ideal Cement Company	Castle Hayne	New Hanover
Webster Brick Company	Draper	Rockingham
Virginia Solite Corporation	Leaksville	Rockingham
Isenhour Brick & Tile Company	East Spencer	Rowan
Carolina Tuff-Lite Corporation	Tuff-lite	Rowan
Boren Clay Products Company	Roseboro	Sampson
Sanford Brick Corporation	Norwood	Stanly
Yadkin Brick Yards, Inc.	Yadkin	Stanly
Carolina Solite Corporation	Aquadale	Stanly
Pine Hall Brick & Pipe Company	#1	Stokes
Kendrick Brick & Tile Company	Monroe	Union

Table 6. Clay Sold or Used in North Carolina 1960-1967

Year	Tons	Value
1960	2,476,000	$1,548,000
1961	2,603,000	1,669,000
1962	2,731,000	1,782,000
1963	2,735,000	1,761,000
1964	3,199,000	2,064,000
1965	3,383,000	2,162,000
1966	3,381,000	2,241,000
1967	2,997,000	2.012,000

The above figures represent the estimated value of the raw clay as mined. As a result, the figures do not begin to indicate the true value of the clay and shale industry to the State of North Carolina. For several years the state has been and continues to be the leading producer of brick. In 1967, North Carolina manufactured 840,500,000 bricks valued at $25,400,000 or 11.4 percent of the total production of the United States. This does not include the value of vitrified sewer pipe, lightweight aggregate and other structural clay products manufactured in the state.

Minerals of the kaolin group which constitute high grade china clay or kaolin are formed by the weathering of other mineral particles, especially feldspar. There are two principal types of deposits: (1) residual, formed by the disintegration and decomposition of the parent rocks in place, and (2) sedimentary, in which the kaolin has been transported from its original source and deposited in water. Although small deposits of sedimentary kaolin are known to occur in North Carolina, the known economically valuable ones are of the residual type.

North Carolina has for many years been the leading state in the United States of America in the production of primary or residual kaolin. The kaolins of the state are widespread over the Piedmont and Mountain areas. Deposits in the Piedmont plateau are small and production over the years has been negligible. The commercially important kaolin deposits are found in two districts in the Mountain area: (1) the Franklin-Sylva district which includes parts of Haywood, Jackson, Macon and Swain counties and (2) the Spruce Pine district which includes Avery, Mitchell and Yancey counties. Formerly, all the kaolin produced in North Carolina came from the Franklin-Sylva district, but in more recent years, the Spruce Pine district has become the leading producer. During the period 1960-1967 inclusive, all the production came from the Spruce Pine district. The Harris Clay Company produced kaolin in Avery County each year of the period, while Roy Grindstaff produced kaolin in Mitchell County in 1965.

Feldspar

Feldspar mining began in North Carolina in 1911 when Carolina Mineral Company shipped small amounts from the Deer Park mine near Spruce Pine, Mitchell County. In 1914, North Carolina became a steady producer and by 1917 the leading producer of feldspar in the United States, a position it still holds. In 1917, North Carolina's production of crude feldspar amounted to one-third of that of the nation and by 1962 had grown to approximately 50 percent of the domestic production.

Most of the feldspar mined in North Carolina has come from the Spruce Pine district of Avery, Mitchell and Yancey counties. Other counties that have produced feldspar include Buncombe, Haywood, Jackson, Swain and Transylvania west of the Blue Ridge mountains and Cleveland County in the Piedmont. At one time, Swain County ranked second in North Carolina to the Spruce Pine district in the production of feldspar. Recently, that distinction has passed to Cleveland County where Foote Mineral Company and Kings Mountain Mica Company have produced feldspar as a byproduct of spodumene concentration and flake-mica processing.

In the early days of production, all the feldspar mined in North Carolina was shipped to grinding mills in other states, but by 1967, 5 of 19 feldspar grinding mills in the United States were in North Carolina. As a result, North Carolina is the leading producer of both crude and ground feldspar in the United States.

Table 7. Crude Feldspar Produced in North Carolina 1954-1967

Year	Long Tons	Value
1954	230,744	$2,220,707
1955	242,724	2,184,793
1956	255,637	3,191,559
1957	233,439	2,728,153
1958	224,647	2,519,713
1959	292,114	2,934,552
1960	271,000	2,781,000
1961	252,000	2,476,712
1962	245,000	2,373,000
1963	268,000	2,821,100
1964	324,000	2,342,000
1965	279,000	3,153,000
1966	302,000	3,157,000
1967	265,690	3,112,655

Table 8. Ground Feldspar Sold by Merchant Mills in North Carolina 1954-1967

Year	Short Tons	Value
1954	210,804	$3,123,096
1955	249,855	3,850,265
1956	261,430	4,044,653
1957	237,655	3,406,055
1958	232,625	3,120,619
1959	279,448	3,251,522
1960	275,000	3,100,000
1961	267,000	2,769,000
1962	257,000	2,863,000
1963	297,400	3,611,300
1964	361,000	3,882,000
1965	303,000	3,408,000
1966	337,000	3,700,000
1967	307,580	3,723,133

Table 9. Producers of Crude Feldspar in North Carolina, 1967

Foote Mineral Company
International Minerals and Chemical Corp.
Kings Mountain Mica Company
Lawson United Feldspar & Minerals Company
The Feldspar Corporation

Table 10. Producers of Ground Feldspar in Nort Carolina, 1967

Foote Mineral Company
International Minerals & Chemical Corporatio
Lawson United Feldspar and Minerals Compan
The Feldspar Corporation

Gem Stones

A wide variety of gem stones and gem material were collected from 25 or more counties in Nort Carolina during the period 1960-1967, inclusive. Among the minerals reported were amethyst, bery corundum, emerald, feldspar, garnet, hiddenite, kyanite, opal, ruby, sapphire, quartz and miscellaneous mineral and rock specimens. The reported valu of such materials collected in the state during thi period varied from a low of $2,375 in 1960 to high of $25,000 in 1967 and averaged $12,132 fo each year of the period. However, this total is probably considerably less than the true value of all gen materials found in the state during the eight yea period covered by this report because most of th material is found by individual collectors and is no reported.

North Carolina contains more than 25 varieties o gem stones, gem materials and mineral and rocl materials sought by collectors and is well known an highly regarded as one of the more important gen stone producing states of the United States. Th importance of North Carolina as a source of gen stones, resulted from the discovery and productio of gem stones as a byproduct of other form of mining. Attempts to mine mica and othe minerals from pegmatite dikes and corundum fron peridotite masses in the last 30 years of the nineteenth century led to the discovery of some beautiful beryls, garnets, rubies, amethysts and other minerals. Attempts at systematic mining for gem materials as a byproduct of other forms of mining ha developed into a popular hobby and past time in th state.

As a result, in recent years a number of ol mines and mine dumps that yielded gem material in the latter part of the nineteenth century hav been opened to collectors and interested persons Individuals are permitted to collect on such properties for a daily or hourly fee and may keep any gen materials found. There are several such operation in the state that have proved to be very popular Among these are those along Cowee Creek in Macon County, at Crabtree Mountain, Mitchell County and at Hiddenite, Alexander County.

Graphite

Graphite, also known as black lead and plumbago, is one of the varieties of elemental carbon. It is a soft, black mineral with a greasy feel that occurs in North Carolina most commonly as disseminated flakes in gneisses and schists or as scaley or compact earthy masses. Graphite is used in making crucibles, in foundary facings, lubricants, pencils, crayons, paint, stove polish, commutator brushes and for many other uses.

Graphite is most commonly associated with gneisses, schists, and metamorphosed limestones but also occurs in pegmatites and other intrusive formations. Some of the better known occurrences in North Carolina are found in Alexander, Catawba, Cleveland, Macon, McDowell, Rutherford, Wake and Yancey counties. No natural graphite has been produced in North Carolina in several years. During the period of this report, Great Lakes Carbon Company produced synthetic graphite at Morganton from imported materials.

Lithium

The lithium industry of the United States has experienced tremendous growth since 1950, and North Carolina has become the principle domestic producer of lithium minerals. An important factor in this rapid growth is the large volume of high-grade ore that has been discovered in the Kings Mountain district of Cleveland, Gaston and Lincoln counties, North Carolina.

In 1955, Norton and Schlegel, United States Geological Survey Bulletin 1027G, "Lithium Resources of North America," pointed out that the United States contains an estimated and inferred reserve of 138,800,000 units of Li_20 of which 128,000,000 are in the Kings Mountain district. In 1956, Broadhurst, North Carolina Department of Conservation and Development, Information Circular 15, "Lithium Resources of North Carolina," estimated that lithium ore in the Kings Mountain district which appeared favorable for mining amounted to 41,500,000 tons with a lithium content of 1.25 percent or approximately 55,030,000 units of Li_20.

In 1960, Kesler, American Institute of Mining, Metallurgical and Petroleum Engineers, Industrial Minerals and Rocks, Chapter 24, "Lithium Raw Materials," stated, "by June 30, 1959, the crude ore reserves of Foote Mineral Company amounted to 20,746,297 tons measured (1.53 pct. Li_20) and 15,769,075 tons indicated, based on the completed second stage of drilling on a tract 6,000 feet long. Lithium Corporation of America has a computed reserve of 9,683,000 tons (1.3 pct. Li_20) as a result of drilling. Indicated reserves on other properties total at least 15,000,000 tons averaging about 1.35 pct. Li_20. These reserves apply to some of the better properties, but only to limited depth and to only a small proportion of the district. Consequently, the ultimate reserves are probably larger than those given in all earlier estimates which were based largely on inference."

These reserves constitute the world's largest proved reserves of lithium ore and assure North Carolina a prominent place in the lithium industry for many years.

During the period 1960-1967, Foote Mineral Company mined and concentrated spodumene at its Kings Mountain operation. These lithium raw materials were processed to lithium primary products at Sunbright, Virginia. The production and value of spodumene in North Carolina increased each year of the period over the preceeding year beginning with 1961.

Lithium Corporation of America processed imported ore to lithium primary products at its Bessemer City, North Carolina plant. In 1967, Lithium Corporation of America merged with Gulf Sulphur Corporation to form a new organization, Gulf Resources and Chemical Corporation. Lithium Corporation of America thus became a subsidiary of the new organization.

Detailed production figures are not available for publication, but in 1967, lithium ore production in North Carolina increased 14 percent in tonnage and 25 percent in value over 1966. During the same period, imports of lithium minerals, more than 90 percent of which came from Southern Rhodesia, almost tripled that of 1966.

Mica

Mica mining began in North Carolina in 1867, but production figures were not kept until 1880. Since that time, North Carolina has been the principal producer of mica in the United States. The United States is the world's leading consumer of mica, but does not produce enough to meet domestic needs. As a result, the amount of mica produced and the value of this production have varied widely depending upon economic conditions and demands for mica.

In 1900, the first year the State of North Carolina collected and published production figures, the sheet mica mined was estimated at 304,180 pounds valued at $65,200. During the next 8 years, the production and price increased irregularly to 1,296,274 pounds in 1909 valued at $122,246. Production and price again varied widely during the next 10 years and in 1919, reached 1,021,306 pounds valued at $331,498. Production exceeded 1,000,000 pounds in 1920 and 1923 but declined sharply in the late 1920's and early 1930's. By 1937, production rose to 1,044,328 pounds valued at $218,176. The amount and value of sheet mica produced in North Carolina from 1935 through 1967 is shown below.

Table 11. Sheet Mica Sold or Used by Producers in North Carolina 1935-1967

Year	Pounds	Value
1935	512,590	$ 77,598
1936	730,446	119,653
1937	1,044,328	218,176
1938	632,646	87,879
1939	401,170	69,344
1940	1,002,646	218,154
1941	1,614,868	318,783
1942	1,654,895	505,634
1943	1,901,120	1,722,324
1944	814,874	1,530,625
1945	563,990	243,058
1946	424,791	135,505
1947	210,816	84,275
1948	257,926	44,648
1949	507,935	113,058
1950	483,736	102,179
1951	464,948	127,202
1952	595,331	644,075
1953	619,895	1,308,494
1954	479,221	1,787,197
1955	553,444	2,745,254
1956	770,903	2,135,000
1957	577,607	1,375,000
1958	521,701	1,722,000
1959	505,623	1,755,000
1960	430,193	1,539,007
1961	390,870	2,237,000
1962	320,305	867,007
1963	92,961	12,604
1964	242,662	58,481
1965	713,293	184,650
1966	4,500	1,000
1967	4,500	1,000

The increased production and value of sheet mica from North Carolina during the years 1940-1944 inclusive were the result of government support through its agency, Colonial Mica Corporation, which was the sole buyer of domestic strategic mica. Prices were controlled and amounted to as much as $8 per pound. On November 30, 1945, following the close of the war, all restrictions were lifted and domestic sheet mica had to compete with cheap imports.

In 1952, the federal government began a program of purchasing domestically produced mica at above market prices for its stockpile of strategic defense minerals. This program was to expire on June 30, 1962, or when the original quota of 25,000 short tons of hand-cobbed mica, or its equivalent, was reached. This quota was reached on June 7, 1962, and the program was terminated.

The effect of this program on the amount and value of sheet mica produced in North Carolina between 1953 and 1962 inclusive and since 1962, is shown in the above table. All the sheet mica produced in North Carolina during the year 1967 was a byproduct of other types of mining.

In 1900, the production of scrap mica amounted to 5,945 tons valued at $36,262. Production declined sharply the next year and did not again reach 5,000 tons until 1923 when the production was 5,005 tons valued at $65,764. Production gradually rose to 11,831 tons in 1935 valued at $153,553. The tonnage and value of scrap mica produced in North Carolina from 1935 to 1967 inclusive is shown below.

Table 12. Scrap Mica Produced in North Carolina 1935-1967

Year	Short Tons	Value
1935	11,831	$ 153,553
1936	10,840	131,138
1937	12,988	209,212
1938	11,959	161,598
1939	13,913	184,377
1940	11,595	173,327
1941	18,234	268,596
1942	24,145	485,560
1943	25,295	516,637
1944	29,775	750,285
1945	30,682	709,334
1946	39,100	887,901
1947	38,655	844,086
1948	44,428	992,303
1949	24,801	640,374
1950	48,193	1,281,000
1951	52,550	1,441,886
1952	58,576	1,551,071
1953	55,184	1,520,381
1954	61,049	1,475,122
1955	60,887	1,377,035
1956	47,000	1,065,000
1957	53,000	1,173,000
1958	31,000	1,041,000
1959	48,000	1,212,000
1960	47,000	1,100,000
1961	54,000	1,010,000
1962	62,000	1,384,000
1963	62,000	1,497,000
1964	64,000	2,026,682
1965	72,000	1,986,970
1966	63,000	2,348,469
1967	69,639	1,751,000

Table 13. Producers of Crude Mica in North Carolina in 1967

Deneen Mica Company
Eugene Ownby
Foote Mineral Company
Harris Mining Company
International Minerals & Chemical Company
Kings Mountain Mica Company
Lawson United Feldspar & Minerals Company
The Feldspar Corporation
U.S. Gypsum Company

Table 14. Producers of Ground Mica in North Carolina in 1967

Company	Process
Asheville Mica Company	Dry
Carolina-Southern Manufacturing Co.	Dry
Deneen Mica Company	Dry
Diamond Mica Company	Wet
Franklin Mineral Company	Wet
Harris Mining Company	Dry
Lawson & Boone Mica	Dry
The English Mica Company	Wet and dry

The major mica-producing areas of North Carolina are the Spruce Pine district which includes Avery, Mitchell and Yancey counties; the Franklin-Sylva district in Haywood, Jackson and Macon counties; and the Shelby district of Cleveland, Lincoln and Gaston counties. Crude mica has been mined from many other counties in the Piedmont and Mountain areas of the state. In 1967, Mitchell County was the leading producer and reported a production of 23,785 tons valued at $369,849. Cleveland was second with a reported tonnage of 19,224 tons valued at $574,655. The other three producing counties in the order of importance were Yancey, Avery and Macon.

Olivine

Olivine is a magnesium silicate $(Mg,Fe)_2SiO_4$ that ranges from forsterite Mg_2SiO_4 to fayalite Fe_2SiO_4 in composition. No sharp line can be drawn between the two. Olivine crystallizes in the orthorhombic system and crystals are usually tabular in habit. Olivine normally occurs in granular masses that have an olive-green color. It is a common constituent of basic igneous rocks such as basalt, gabbro and peridotites. Dunites are varieties of peridotite that consist essentially of pure olivine with accessory primary minerals such as chromite, spinel, enstatite, bronzite and magnetite.

Olivine was first recognized and described in North Carolina by Kerr in 1875 as "chrysolitic sandstone." Later the olivine deposits were recognized as dunites and described as such by Pratt and Lewis in 1905. In 1942, Hunter stated that "More than 275 peridotite formations, many of which are dunites, occur in North Carolina and Georgia. These deposits lie west of the Blue Ridge Mountains and occur in a belt less than 50 miles wide and about 300 miles long."

Olivine was first produced in North Carolina about 1933 for experimental use as a basic refractory in the steel industry. Since that time, the state has been a small but steady producer. The average annual production of olivine from 1954 through 1959 was 11,137 short tons valued at $166,777 and averaging $15.09 per ton. From 1959 through 1962, there was an increase in production and value. The tonnage and value declined in 1963 but has increased each year since to a tonnage of 21,744 tons, valued at $443,655 in 1967.

Olivine has been found to be a valuable material to replace chromite in steel furnaces and for use above the slag line in nonferrous furnaces. The latest reports indicate that North Carolina olivine is being successfully used in refractories, molding sand and as a slag conditioner. Other potential uses include high-temperature cements, as a source of magnesium salts and special fertilizers. Because of its high magnesia (MgO) content, olivine is a potential source of magnesium metal and various magnesium compounds.

Perlite

North Carolina contains large amounts of volcanic fragmental and flow rocks in the Carolina Slate Belt which lies along the eastern edge of the Piedmont Plateau. These rocks are so old and highly metamorphosed that deposits of perlite, pumice, pumicite and volcanic cinder, the glassy materials that are extensively worked in the western part of the United States, are not found in the area. However, Carolina Perlite Company, Inc., expanded imported perlite for use as a lightweight aggregate at its Gold Hill plant in Rowan County during the period 1960-1967.

Phosphate

The first recorded discovery of phosphate in North Carolina was made in 1883. In 1884, C. W. Dabney reported that in February 1883, he examined a phosphate deposit at Castle Hayne, New Hanover County and later the same year conducted an examination of phosphate deposits in Duplin, Sampson and Pender counties. Late in 1883, W. B. Phillips reported that in August 1883, he examined a phosphate deposit in Duplin County and followed up this work by examining other deposits in the same area.

In 1888, R. A. F. Penrose, U.S.G.S. Bulletin 46, "Nature and Origin of Deposits of Phosphate of Lime," gave a brief description with chemical analyses of the character and occurrence of phosphate deposits in Duplin, Sampson, Pender, Onslow and New Hanover counties. In the Duplin-Sampson area, the phosphate occurred as beds of impure phosphatic material 10 to 20 inches thick in sand and clay. In the Castle Hayne area, the phosphate beds consisted of conglomerate in which the pebbles were phosphate and the matrix was a white calcareous rock. The deposits were associated with materials of Eocene age. The bone phosphate of lime content of the materials varied from 10 to 20 percent. According to Penrose, at least two attempts were made to produce phosphate from these deposits between 1883 and 1888 without success. One attempt was made in the Duplin-Sampson County area and the other was made in the Castle Hayne area.

In 1891, the General Assembly of North Carolina passed laws regulating the mining of phosphate from the waters of navigable streams in the state, but no records of phosphate production in North Carolina prior to the discovery of phosphate in Beaufort County have been found.

Interest in phosphate deposits of North Carolina was revived in the early 1950's when Amco Exploration, Inc., 61 Broadway, New York City, New York, a subsidiary of American Metals Company now American Metals Climax, became interested in the Beaufort County area. Amco Exploration's interest in prospecting for phosphate in Beaufort County was initiated by the finding of phosphate in well cuttings acquired from well drillers who had drilled water wells in the area.

Under date of July 18, 1952, the State of North Carolina granted to Arnold M. Davis of Raleigh a lease on phosphate-bearing minerals beneath the Pamlico River and its tributaries in Beaufort County, with the understanding that the lease was to be assigned to Amco Exploration, Inc. The area leased was bounded on the west by west longitude 77° 9′ which is a line approximately 6 miles upstream from the city of Washington, North Carolina, and on the east by west longitude 76° 35′ which is a line approximately 30 miles downstream from Washington. The lease was assigned to Amco Exploration, Inc., on August 7, 1952, and accepted on September 9, 1952.

On May 11, 1953, Amco Exploration, Inc., after drilling approximately 50 test holes and carrying out other exploration work cancelled the lease with the following explanation: "We hereby advise you that we have actively explored in the vicinity of Pamlico Sound by geologic investigation and well drilling and have failed to make any discovery of a commercial body of phosphate-bearing minerals or other minerals."

In the spring of 1956, Alan Swindell had a water well drilled on his farm which is located about 4 miles northwest of Pantego in Beaufort County. The well penetrated a considerable thickness of phosphate. While setting a screen, the driller removed several hundred pounds of phosphate material from the well. P.M. Brown, Geologist, U.S. Geological Survey, who was carrying out ground-water studies in the area on a cooperative agreement between the U.S. Geological Survey and the North Carolina Department of Conservation and Development, collected a 100 pound sample of this material which was sent to the North Carolina State College Minerals Research Laboratory in Asheville. Laboratory studies showed this sample to contain 47 percent phosphate minerals which assayed 60.2 percent BPL (bone phosphate of lime). This represented a recovery of 86.6 percent of the total BPL present.

Based on ground-water studies carried out in the area in 1955, 1956 and early 1957, and on data from test wells drilled for phosphate in 1952 and 1953, prior to the ground-water studies, Brown prepared a report which was presented before a meeting of the Southeastern Section of the Geological Society of America at Morgantown, West Virginia in April 1957, and published in Economic Geology in 1958. This report indicated the presence of a phosphate field of major economic importance in Beaufort County.

According to this report, the deposits which are regarded as being of middle Miocene age, lie unconformably on limestone of Eocene age and are unconformally overlain by sands, clays, shale limestones and marls of late Miocene age. The phosphate beds are burried beneath strata ranging in thickness from 45 to 250 feet and underlie an area of approximately 450 square miles. The total thickness of the phosphate beds throughout the area range from a feather edge to approximately 100 feet.

The phosphate column consists of phosphatic sand, clay and interbedded shell limestone. The sands are composed of pellets of brown sand-size collophane (probably carbonate-fluorapatite) and sand-size, flat sided, angular quartz grains and some silt, clay and organic materials. These materials have a median diameter of 0.50 to 0.25 mm. The P_2O_5 content of the phosphate materials varies from 2 or 3 percent to 21 percent and is apparently proportionate to the collophane content throughout the area.

The report summarized the origin of the phosphate deposits of Beaufort County as follows:

"Chemical analyses of artesian waters from the phosphorites and from limestone overlain by phosphorites reveal significantly greater concentrations of iodine and bromine in solution than are present in water from overlying sediments or from underlying limestones not overlain by phosphorites. Such anomalies, if present in other similar terraines, may indicate the presence of buried phosphorites."

In December 1956, Kennecott Copper Corporation and Sun Oil Company sent representatives to Beaufort County to investigate the phosphate potential of the area. In the spring of 1957, Bear Creek Mining Company, a subsidiary of Kennecott Copper Corporation, New York City, N.Y., and General Crude Oil Company, Houston, Texas, both began acquiring land and exploring for phosphate.

In April 1957, representatives of Bear Creek Mining Company appeared before the Mineral Resources Committee at a meeting of the Board of Conservation and Development in Kinston, outlined in part a proposed program for exploring the phosphate deposits of Beaufort County and stated that in the near future, Bear Creek Mining Company might request a lease on phosphate beneath the bottoms of Pamlico and Pungo rivers, totaling approximately 60,000 acres.

On May 7, 1957, representatives of Bear Creek Mining Company appeared before a called meeting of the Mineral Resources Committee of the Board of Conservation and Development in Raleigh and presented a proposal to lease phosphate deposits beneath the bottoms of Pamlico and Pungo rivers at a flat royalty of 20 cents per long ton of dry mechanically concentrated phosphate-bearing material removed from the area. The committee rejected this proposal on the grounds that it did not provide for any increase in prices and requested that the offer to lease be amended by the addition of an esculator clause providing for changes in the price of mechanically concentrated phosphate materials. The representatives of Bear Creek Mining Company agreed to consider this request and renew the offer to lease at a later date.

About the middle of May 1957, representatives of General Crude Oil Company came to the offices of the Department of Conservation and Development, expressed an interest in phosphate beneath the bottoms of Pamlico and Pungo rivers and requested information on how this phosphate might be leased. They were informed that the matter was being handled by the Board of Conservation and Development through its Mineral Resources Committee. They were given the names and addresses of the members of the Mineral Resources Committee and advised to contact these members and arrange to present a proposal to lease phosphate beneath the bottoms of Pamlico and Pungo rivers.

On June 10, 1957, the Mineral Resources Committee met at the Eseeola Inn in Linville to consider the amended proposal of Bear Creek Mining Company. General Crude Oil Company was notified of this meeting and asked to send representatives to present any proposal that company might have to lease the same deposits. Representatives of both Bear Creek Mining Company and General Crude Oil company attended the meeting.

The Committee first heard an amended proposal of Bear Creek Mining Company. The amended proposal was considered satisfactory and the representatives of Bear Creek Mining Company were told that the request as amended would be recommended to the Board of Conservation and Development at the July, 1957 meeting unless a better offer was received. The Committee then heard representatives of General Crude Oil Company. They had no definite proposal to present at that time. They stated that the Board of Directors of General Crude Oil Company would meet in Houston, Texas, within one week and that a definite proposal to lease phosphate beneath the bottoms of Pamlico and Pungo rivers would be furnished the Chairman of the Mineral Resources Committee by July 1, 1957, and in time to be considered at the July 1 and 2, 1957, meeting of the Board of Conservation and Development.

The Board of Conservation and Development met in regular session at Morehead City on July 1, 1957. The Mineral Resources Committee met at 2:30 that afternoon. Representatives of Bear Creek Mining Company were present to support their request to lease phosphate deposits beneath the bottoms of Pamlico and Pungo rivers. No request or information on phosphate leasing had been or was received from General Crude Oil Company and at 6:00 P.M., the committee prepared a resolution recommending that the proposal of Bear Creek Mining Company be accepted. No information had been received from General Crude Oil Company by the time of the final session of the Board of Conservation and Development on Tuesday afternoon, July 2, 1957. The Board approved the recommendation that the proposal of Bear Creek Mining Company to lease phosphate deposits beneath the bottoms of Pamlico and Pungo rivers be accepted and instructed the Director and State Geologist to prepare a lease in consultation with the Attorney General.

After some unexpected delays, the proposed lease to Bear Creek Mining Company covering phosphate deposits beneath the bottoms of Pamlico and Pungo rivers was completed and presented to the Governor and Council of State early in December 1957.

The announcement in the press early in 1957 that Bear Creek Mining Company and General Crude Oil Company were acquiring land and exploring for phosphate in Beaufort County, North Carolina, attracted considerable interest and brought inquiries from other companies interested in phosphate. The announcement in July 1957, that the Board of Conservation and Development had authorized leases on phosphate deposits beneath the bottoms of

Pamlico and Pungo rivers to Bear Creek Mining Company subject to the approval of the Governor and Council of State further increased interest in the deposits. As a result, by the time the porposal to lease the deposits reached the Governor and Council of State early in December 1957, practically every major company in the United States having any real interest in phosphate had either inquired about the deposits or sent representatives to visit the area.

In view of the widespread interest that had developed in the phosphate deposits of North Carolina, the Council of State in December 1957, considered briefly the proposal to lease phosphate deposits beneath the bottoms of Pamlico and Pungo rivers to Bear Creek Mining Company and requested time to study it in some detail.

On January 7, 1958, the Governor and Council of State considered further the proposal to lease phosphate deposits beneath the bottoms of Pamlico and Pungo rivers to Bear Creek Mining Company. After some discussion, the Council of State deferred action on the proposed lease to Bear Creek Mining Company and instructed the Board of Conservation and Development to negotiate further on the proposal and give all companies that might be interested in phosphate deposits beneath the bottoms of Pamlico and Pungo rivers an opportunity to request a lease.

Letters were written to Bear Creek Mining Company, General Crude Oil Company and all other companies that had shown any interest in phosphate deposits in North Carolina. Each Company was asked, if interested, to present a definite proposal to lease the phosphate deposits beneath the bottoms of Pamlico and Pungo rivers in blocks of 10,000, 20,000, 30,000 acres or as a whole. A reply was received from each company querried. Only Bear Creek Mining Company expressed an interest in leasing the deposits.

In March 1958, representatives of Bear Creek Mining Company met with representatives of the State of North Carolina in Raleigh and indicated that an offer to lease the phosphate deposits beneath the bottoms of Pamlico and Pungo rivers would be renewed at the April 1958 meeting of the Board of Conservation and Development. Shortly before that meeting, Bear Creek Mining Company notified the Governor of North Carolina and the Director of the Department of Conservation and Development that it was withdrawing its offer. During the year 1958, both Bear Creek Mining Company and General Crude Oil Company withdrew from the state.

Between June 1, 1960, and January 31, 1961, A. L. Nash, Jr., of Concord, North Carolina carried out three exploratory attempts to mine phosphate in the vicinity of Bayview, Beaufort County, North Carolina. These experiments consisted of sinking one 8-inch pipe to the top of the phosphate horizon and another 8-inch pipe to the bottom of the phosphate horizon. The distance between pipes was approximately 20 feet. Water was then pumped into the pipe ending at the top of the phosphate horizon at the rate of about 1,000 gallons per minute which forced the phosphate sand to the surface. Compressed air at 70 pounds pressure through a ½-inch pipe was used to keep the sand agitated. These experiments were successful to a degree, but each failed when enough sand had been removed for the roof to cave and the water seal to be lost.

On October 2, 1961, representatives of Cherokee Securities Corporation, 270 Madison Avenue, New York, N.Y., appeared before the Mineral Resources Committee of the Board of Conservation and Development on behalf of Joint Ventures, a group of landowners in Beaufort County, who owned 30,000 to 40,000 acres of phosphate lands, and requested the State of North Carolina to make available $60,000 to pilot the process Mr. Nash used. The request was taken under advisement.

The experiments of A. L. Nash, Jr., created new interest in the phosphate deposits of Beaufort County, North Carolina. Texas Gulf Sulphur Company which had become interested in North Carolina in 1958 became seriously interested in the phosphate deposits of Beaufort County by the middle of 1961 and began lowering gamma-ray probes into farm water wells to determine the depth to phosphate and the thickness and extent of the deposits. About the middle of October, Leo J. Miller, representing Texas Gulf Sulphur Company came to Raleigh, discussed the program of Texas Gulf Sulphur Company and requested information on the possibility of leasing phosphate beneath a part of the bottom of Pamlico River.

About the middle of November 1961, L. L. McMurray, representing Magnet Cove Barium Corporation, one of the Dresser Industries, came to Raleigh, announced that Magnet Cove Barium Corporation was interested in phosphate in North Carolina and requested information on how a lease on phosphate deposits beneath the bottom of Pungo River might be obtained.

On December 12, 1961, C. H. Burgess, representing Kennecott Copper Corporation, came to Raleigh and spent an hour discussing the phosphate deposits of Beaufort County with the Director of the Department of Conservation and Development and the State Geologist. Mr. Burgess indicated that Kennecott Copper Corporation through Bear Creek

Mining Company was again interested in phosphate n Beaufort County and might want a lease on a part or all of the phosphate beneath the bottoms of Pamlico and Pungo rivers.

At the winter meeting of the Board of Conservation and Development at High Point on January 22 and 23, 1962, representatives of the companies desiring a lease on phosphate beneath the bottoms of Pamlico and Pungo rivers and all others interested in the phosphate deposits of Beaufort County were asked to meet with the Mineral Resources Committee at 2:00 o'clock on the afternoon of January 22, 1962. Representatives of Texas Gulf Sulphur Company, Bear Creek Mining Company, Magnet Cove Barium Corporation and several people interested in the economic impact of the phosphate resources of Beaufort County on the economy of eastern North Carolina were present. After a three hour session, during which the various phases of phosphate leasing beneath the bottoms of Pamlico and Pungo rivers and the benefits and harm that might come from the leasing of these deposits were discussed fully, the Mineral Resources Committee prepared two resolutions which were adopted by the Board of Conservation and Development on January 23, 1962. The first resolution recommended that a gamma-ray logging study be made of he phosphate deposits of Beaufort County. The econd resolution recommended the preparation of program for leasing phosphate deposits beneath he bottoms of Pamlico and Pungo rivers and other aters of the area on a sealed-bid basis.

Relative to the study of phosphate, the Committee ecommended, "That a gamma-ray logging study of he phosphate deposits in Beaufort County be made cooperation with the United States Geological urvey at a cost of approximately $30,000.00. The nited States Geological Survey will furnish the quipment and pay $15,000.00 of the cost if the tate of North Carolina furnishes a like amount. It recommended that Beaufort County be asked to ntribute $5,000.00 of the state's share."

On February 5, 1962, the County Commissioners Beaufort County authorized an appropriation of ,000 to aid in the gamma-ray logging study of the osphate deposits of Beaufort County. Field work gan in March 1962, and was completed about May 1963. A detailed report of this study consisting 131 pages of text, 1 table, 12 plates and 8 figures s published by the North Carolina Department of nservation and Development, Division of Mineral sources in 1965, as Bulletin 79, "Description of e Pungo River Formation in Beaufort County, rth Carolina."

The resolution relative to the leasing of phosphate deposits beneath the bottoms of Pamlico and Pungo rivers stated: "It is recommended that the Board of Conservation and Development authorize the Mineral Resources Committee to prepare a program for leasing phosphate deposits beneath the bottoms of Pamlico and Pungo rivers and other waters of the area on a sealed-bid basis. It is recommended that this program be worked out in cooperation with the Attorney General's office, the Council of State and all other interested state agencies and be presented to the Board of Conservation and Development before proceeding further in the matter of leasing these deposits."

Accordingly, an option-to-lease proposal was prepared and presented to the Board for approval at New Bern on April 2 and 3, 1962. In preparing the proposal, the Pamlico and Pungo rivers were divided into five minute blocks by the use of longitude and latitude. The Pamlico River was divided into six blocks designated A,B,C,D, E, F, and the Pungo River was divided into three blocks designated G,H, I. The option-to-lease proposal contained a five year option period and spelled out the terms and conditions under which the option might become a lease. The biddable part of the proposal was to be a percentage royalty of the market value of the first marketable product of phosphate and other minerals. An option period of five years was established during which time certain expenditures for exploration were required. During the option period, a rental of 25 cents per acre was required for the area under option. The option was to become a lease at any time during the five year period at the request of the holder of the option. When the option became a lease, the holder must pay three dollars per acre per year rent plus the royalty bid.

The Board of Conservation and Development approved the proposal and requested the Department of Administration to advertize the deposits and receive sealed bids on them.

Bids were receivable through 2:30 P.M., June 4, 1962. Bids were received from Magnet Cove Barium Corporation, Texas Gulf Sulphur Company and Pamlico Mining and Chemical Corporation (Pamlico Mining and Chemical Corporation was created jointly by Kennecott Copper Corporation and American Agricultural Chemical Company as of May 1, 1962, to engage in exploration, mining and processing phosphate.).

Magnet Cove Barium Corporation bid 3.7 percent of the market value of the first marketable product of phosphate recovered from blocks G,H and I, of the Pungo River. Texas Gulf Sulphur Company bid

12.5 percent of the market value of the first marketable product of phosphate received from block D of the Pamlico River. Pamlico Mining and Chemical Corporation bid 5.259 percent of the market value of the first marketable product of phosphate recovered from Block D of the Pamlico River. On July 10, 1962, the Board of Conservation and Development in session at Boone, North Carolina, accepted the bids of Texas Gulf Sulphur Company and Magnet Cove Barium Corporation. On September 27, 1962, option-to-lease proposals recommended for Texas Gulf Sulphur Company and Magnet Cove Barium Corporation were approved by the Council of State and signed by the Governor of North Carolina.

In 1961, Texas Gulf Sulphur Company began an extensive exploration and land acquisition program in Beaufort County that centered around the vicinity of the Lee Creek area, about 10 miles north of Aurora. The successful bid on Block D of Pamlico River, which contains some 9,202 acres brought the holdings of Texas Gulf Sulphur Company to more than 30,000 acres of phosphate land in Beaufort County. These holdings justified a full-scale test mining operation which was started in the fall of 1963. A 20-inch suction dredge was used to remove the overburden and excavate the phosphate ore from the test pit which reached a diameter of about 900 feet and a depth of 145 feet. Approximately 900,000 cubic yards of earth were removed during the test mining program and over 100,000 tons of phosphate ore were stored for pilot plant concentration studies.

The test mining program was completed in January 1964. The results of this program demonstrated to Texas Gulf Sulphur Company that phosphate mining in the Lee Creek area could best and most economically be carried out from a dry pit by draglines.

On April 3, 1964, Texas Gulf Sulphur Company announced that 45 million dollars would be invested in a mining operation at Lee Creek designed to recover 3 million tons of phosphate concentrate annually. On April 1, 1966, Texas Gulf Sulphur Company made the first shipment of phosphate concentrate mined and processed at its Lee Creek facilities. By the end of June 1966, the mine was producing 18,000 tons of ore per day and the mill was producing 6,000 tons of concentrate per day that averaged 30.7 percent P_2O_5.

On May 27, 1964, the State of North Carolina offered for lease 992 acres underlying the mouth of Durham Creek in Beaufort County for phosphate mining. Texas Gulf Sulphur Company and Phillips Petroleum Company were the only bidders on this area. At the July 1964 meeting, the Board of Conservation and Development recommended that a lease on the area be awarded to the Texas Gulf Sulphur Company. On January 4, 1965, the Council of State approved the recommendation that an option-to-lease the area be awarded to Texas Gulf Sulphur Company and the document was signed by the Governor on January 5, 1965.

In April 1965, Texas Gulf Sulphur Company announced plans for a 32 million dollar fertilizer complex to be constructed adjacent to its mining operations at Lee Creek. This fertilizer complex, which was completed and put into operation in 1967 includes the world's largest phosphoric acid plant, a solid fertilizer plant and the world's largest sulphuric acid plant. These plants were designed to produce 640,000 tons of phosphoric acid annually, 415,000 tons of which will be used to produce 357,000 tons of triple superphosphate, while the remaining 220,000 tons of phosphoric acid will be sold in the world market.

On September 27, 1967, the fifth anniversary of its option-to-lease 9,202 acres of phosphate land beneath the bottoms of Pamlico River, Texas Gulf Sulphur Company, acquired a regular mining lease on the land and paid the first year's rent of three dollars per acre.

During 1962 and 1963, North Carolina Phosphate Corporation, formerly Pamlico Mining and Chemical Corporation, acquired several thousand acres of valuable phosphate land on the south side of Pamlico River, adjacent to the holdings of Texas Gulf Sulphur Company. During 1963 and 1964, North Carolina Phosphate Corporation carried out an extensive drilling program on this land. Reports are that a large reserve of high phosphate ore was established, but no definite plans for mining on this land have been announced.

On September 27, 1962, Magnet Cove Barium Corporation was granted an option-to-lease on Blocks G, H and I, of Pungo River totaling 16,31 acres. During the next five years, a more or less continuous program of experimental mining was carried out on these lands. Magnet Cove Barium Corporation appears to have made satisfactory progress in perfecting a unique hydraulic process for economically mining phosphate from depths of over 200 feet below land surface through a system of wells. No announcement as to when mining may be started on these lands has been made, but Magnet Cove Barium Corporation exchanged its option-to-lease for a regular mining lease at the anniversary date of September 27, 1967, and paid the first year's rent of three dollars per acre on the lease.

On February 3, 1964, L. H. Ross of Washington, North Carolina, and Harry Cannon, Sr., and Harry Cannon, Jr., of Lakeland, Florida, requested for themselves a lease on phosphate beneath Block E of Pamlico River and beneath South Creek. At the same meeting, Douglas Harper representing Magnet Cove Barium Corporation of Houston, Texas, requested for that company a lease on phosphate beneath Pungo River from the southern limits of Block G which that company had under option to the mouth of Pungo River; the mouth of Pungo River to be designated by a line drawn due east from Wade Point.

The Mineral Resources Committee offered the following resolution on these requests which was adopted by the Board of Conservation and Development on February 4, 1964:

"The Mineral Resources Committee recommends that the Board of Conservation and Development empower the Director to consider the proposals and to determine the most feasible means of implementing the development of these resources; and that he be empowered to enter into such agreement or arrangement as may be necessary to accomplish such purpose."

On April 27, 1964, H. B. Fowler, E. L. Stout and H. E. Eastmoore, Jr., of FMC Corporation, appeared before the Mineral Resources Committee relative to a lease on phosphate deposits beneath state-owned bottoms as follows: Deposits beneath Pungo River south of Block G to the mouth of Pungo River; deposits beneath South Creek; deposits beneath Block E and Block F of Pamlico River.

The Mineral Resources Committee reiterated the resolution of February 4, 1964 (see above) which the Board of Conservation and Development re-adopted on April 28, 1964.

Pursuant to this resolution, the state-owned submerged lands underlying the southern half of Pungo River and designated as area J, consisting of 3,648 acres, and area K consisting of 3,942 acres, were advertised for lease on a sealed-bid basis. Bids were received until 2:00 P.M., November 24, 1964.

Two companies, Magnet Cove Barium Corporation and FMC Corporation, submitted bids on both areas. Magnet Cove Barium Corporation bid 3.7 percent royalty on the first marketable phosphate product, 10 percent on other minerals and 5 percent on sand and gravel. FMC Corporation bid 7.83 percent royalty on the first marketable phosphate product, 10 percent on other minerals and 10 percent on sand and gravel.

In accordance with the resolution adopted by the Board of Conservation and Development on February 4, 1964, and reiterated on April 28, 1964, the Director with the approval of the Mineral Resources Committee, recommended and the Council of State approved on December 22, 1964, that FMC Corporation be awarded an option-to-lease on Area J and Area K of the Pungo River.

On March 24, 1965, FMC Corporation's option-to-lease became effective. Since that time, an extensive exploration program has been carried out but as of December 31, 1967, no plans for mining in the two areas had been announced.

Sand and Gravel

Sand and gravel occur throughout North Carolina, deposits having been worked in practically every county in the state at one time or another. The most important commercial deposits are those in the Sandhills region of Anson, Richmond, Moore, Hoke, Cumberland and Harnett counties. However, important amounts of sand and gravel are are obtained from the floodplains and stream channels along the major drainage systems in the Piedmont and Mountain regions.

Most of the sand produced is used as an aggregate in the building and construction trade, but some is used as engine sand, molding sand, filter sand and grinding and polishing sand. A high silica sand used in glass making is produced in the Spruce Pine district as a by-product from feldspar flotation. Gravel is used mainly in building, paving and as railroad ballast. Some high-silica gravel is used for chemical purposes.

During the period of this report, sand and gravel accounted for 17 percent of the total mineral production of the state and was exceeded only by granite in tonnage and value. The average annual production was 10,546,250 tons valued at $9,885,476 or about 95 cents per ton. In 1962, the tonnage and value of sand and gravel reached an all time high of 12,516,000 tons valued at $11,457,283.

During 1967, sand and gravel was produced in 81 of the state's 100 counties. Commercial sand and gravel was 66 percent of the total. The remainder was government and contractor production. There were 48 commercial and 72 government and contractor operations. Of the total construction sand and gravel, 68 percent was sand. Forty-eight companies produced sand and gravel in 1967 compared with 47 in 1966. Five of the 48 companies produced 60 percent of the tonnage of commercial sand and gravel. Commercial sand pits were located in 29 counties.

Table 15. Sand and Gravel Sold or Used by Producers in North Carolina, 1960-1967

Year	Short tons	Value	Value per ton
1960	8,801,000	$ 7,453,000	$0.85
1961	9,779,000	8,467,000	0.85
1962	12,516,000	11,457,283	0.91
1963	11,028,000	10,132,000	0.92
1964	11,150,000	10,404,000	0.90
1965	10,499,000	10,076,000	0.95
1966	11,601,000	11,132,000	0.95
1967	10,014,000	9,962,000	0.99

Stone

Stone is the principal mineral product of North Carolina and accounts for approximately 53 percent of the annual tonnage and value of the mineral production of the state. During the period 1960-1967, the average annual production of stone was 33,135,125 tons valued at $57,474,887. This represents an increase of 35 percent in tonnage and 59 percent in value over the period 1954-1959.

Table 16. Stone Sold or Used by Producers in North Carolina, 1960-1967

Year	Short tons	Value
1960	14,721,000	$23,296,000
1961	15,921,000	25,262,000
1962	19,308,000	29,533,000
1963	15,701,000	25,683,000
1964	17,943,000	30,378,000
1965	18,835,000	30,920,000
1966	22,377,000	36,136,000
1967	24,507,000	41,488,000

Table 17. Crushed Stone (granite, etc) Sold or Used by Producers in North Carolina, 1960-1967

Year	Tons	Value
1960	12,518,417	$17,938,484
1961	13,942,760	20,299,486
1962	16,968,535	24,420,000
1963	13,386,785	19,639,789
1964	13,880,414	22,504,892
1965	15,143,769	22,938,943
1966	22,369,109	27,257,314
1967	20,550,669	32,004,377

Table 18. Crushed Limestone and Marble Sold or Used by Producers in North Carolina, 1960-1967

Year	Tons	Value
1960	2,190,354	$ 3,295,031
1961	1,964,676	2,966,041
1962	2,296,787	3,341,291
1963	2,264,207	3,570,853
1964	3,054,646	4,896,843
1965	3,730,431	5,779,814
1966	4,335,105	6,618,271
1967	3,963,699	6,151,940

Table 19. Dimension Stone Sold or Used by Producers in North Carolina, 1960-1967

Year	Tons	Value
1960	41,374	$ 2,062,48
1961	37,973	1,996,47
1962	42,837	1,781,74
1963	52,249	2,481,15
1964	50,178	3,011,97
1965	39,605	2,114,86
1966	38,935	2,331,68
1967	44,388	3,116,98

Most of the stone produced in North Carolina is derived from the crystalline rocks of the Piedmont and Mountain regions and includes granite, gneiss, slate, quartzite, marble and traprock. Some limestone is produced in the Coastal Plain. Approximately 92 percent of the value of the stone produced in North Carolina in 1967 was for crushed stone which had an average value of $1.55 per ton.

Although a wide variety of rocks are quarried in the state, granite constitutes the principal stone deposits. In 1967, the total granite production of the state was 16,975,519 tons valued at $28,822,245 of which 16,652,932 tons valued at $25,581,806 was crushed stone. This made North Carolina the leading state in the production of crushed and broken granite in 1967.

Granitic rocks occur throughout the Piedmont and Mountain regions of the state, but much of the production comes from the central Piedmont section which includes Gaston, Mecklenburg, Lincoln, Cabarrus, Iredell, Rowan, Davidson, Davie, Forsyth, Guilford, Alamance, Caswell and Person counties. Important bodies of granite also occur along the western edge of the Coastal Plain especially in Wilson County and in the northeastern part of the Piedmont comprising Wake, Franklin, Warren, Vance and Granville counties. Sizeable bodies of granite are present in the western Piedmont section in Rutherford, Polk, Gaston, Cleveland, Yadkin, Stokes and Surry counties. One of the larger open face granite quarries of the nation is the Mt. Airy quarry near the town of Mt. Airy, Surry County, where granite monoliths up to 10 X 10 X 60 feet in size may be readily produced. Granite bodies of lesser extent are present in Wilkes, Catawba, Caldwell and Alexander counties.

Massive granites of the Piedmont type are not abundant west of the Blue Ridge Mountains, but granite gneisses are common in some areas. Among the more important, are those in Swain, Henderson, Transylvania, Clay and Macon counties. Other deposits are found in Jackson, Madison, Watauga and Ashe counties.

Extensive deposits of limestone and marble are not present in North Carolina. However, commercial deposits of crystalline limestone and marble occur at several places in the Piedmont and Mountain sections and shell limestone and marl are present at places in the Coastal Plain. All of the major deposits have been quarried at one time or another and most of the stone marketed is crushed stone. Dimension stone, terrazzo chips and agricultural limestone are produced in lesser amounts.

Dimension stone is a relatively small but consistent part of the stone industry in North Carolina. Granite, marble and slate are the principal rock types used. During the year 1967, dimension stone accounted for 7.5 percent of the value of the stone production of the state. The principal producers of dimension stone were:

Comolli Granite Company
Harris Granite Quarries
Jacob's Creek Stone Company
Moretti-Harrah Marble Company
North Carolina Granite Corporation
H. P. Stirewalt

Table 20. Stone Producers in North Carolina, 1967

Ararat Rock Products Company
A. P. Causby Stone Company
A. R. Thompson Construction Company
Blythe Brothers Company
Carl Clement Contractor Company
Cogdill Limestone Company, Inc.
Comolli Granite Company
Fletcher Limestone Company
Franklin Construction Company
Freedey and Duncan
Gilbert Engineering Company
Harris Granite Quarries Company
H. P. Stirewalt
Ideal Cement Company
Jacob's Creek Stone Company
J. L. Colville Company
Lyalls Construction Company
Moretti-Harrah Marble Company
Nantahala Talc and Limestone Company
Nello L. Teer Company
North Carolina Granite Corporation
Rock Products, Inc.
Superior Stone Company
Vulcan Materials Company
Young Stone Company

Talc and Pyrophyllite

North Carolina has been a producer of both talc and pyrophyllite for many years. Both minerals were produced each year of the 1960-1967 period.

Two types of talc deposits occur in North Carolina. One type consists of lens-shaped bodies associated with crystalline dolomitic limestones. The talc in these deposits is high-grade material that is either ground into powder or cut into crayons for industrial uses. Deposits of this type which are located in Cherokee County were mined throughout the period 1960-1967. The other type consists of irregular bodies formed by the alteration of basic magnesian rocks. Deposits of this type occur chiefly west of the Blue Ridge Mountains, but some deposits are found as far east as northern Wake County. These deposits are low-grade and consist of talc associated with soapstone and other minerals. No production was made from these deposits during the period covered by this report.

Pyrophyllite deposits occur along the eastern edge of the Piedmont Plateau in Moore, Montgomery, Randolph, Chatham, Orange, Alamance and Granville counties. North Carolina is the leading producer of pyrophyllite and is third in the nation in the production of talc and pyrophyllite combined.

All of the talc and most of the pyrophyllite produced in North Carolina is either cut into crayons or ground to powder and shipped out of the state for industrial uses. Pyrophyllite refractories are, however, manufactured at Pomona, Guilford County, by the North State Pyrophyllite Company.

Table 21. Talc and Pyrophyllite Sold or Used by Producers in North Carolina, 1960-1967

	Crude		Cut and Ground	
Year	Tons	Value	Tons	Value
1960	100,593	$549,288	96,850	$1,750,271
1961	90,711	367,040	95,576	1,869,317
1962	100,298	432,947	91,367	1,955,974
1963	166,652	446,370	107,767	1,944,827
1964	106,035	495,146	110,552	2,115,510
1965	109,721	556,352	111,913	2,204,589
1966	113,366	576,050	109,778	2,270,623
1967	109,393	512,519	104,843	2,187,177

Table 22. Producers of Talc and Pyrophyllite in 1967

Talc

Hitchcock Corporation

Pyrophyllite

Boren and Harvey
General Minerals Company
Piedmont Minerals Company, Inc.
Standard Mineral Company, Inc.

Quartz

Quartz, commercially referred to as silica, is an important mineral resource that has many industrial uses. It is also the most widespread of all minerals, but commercial deposits of sufficient size and purity to be of economic value are limited. Large deposits of quartz occur chiefly as massive veins, sand beds, sandstone, quartzite and as segregations in pegmatites. The most important uses of quartz are in pottery, scouring soaps, glass, paint, wood filler, tooth powders, sandpapers, flux, chemical ware, in various types of lenses and in the manufacture of ferrosilicon and silicon metal.

There are large deposits of quartz in various sections of North Carolina. Some of these deposits are of sufficient size and grade to qualify as high-silica deposits. However, most of them cannot meet the requirements of high-silica material without some beneficiation. At the present time, most of the production of high-silica material is from deposits of sand and gravel near Lilesville, Anson County and as a byproduct of feldspar flotation in the Spruce Pine district.

During the period of this report, the Laurens Glass Works, Inc., located at Henderson, Vance County and the Ball Brothers plant located at Asheville, Buncombe County, produced a wide variety of quality bottles and jars for the food, beverage, chemical and pharmaceutical industries. The Pittsburg Plate Glass plant at Shelby, Cleveland County, is one of the largest fiber-glass plants in the United States with a minimum capacity of 40,000,000 pounds of glass yarn per year. However, E.I. duPont de Nemours, withdrew from the silicon business and shut down its Brevard, North Carolina plant stating, "the capacity for producing semiconductor grade silicon in the United States is considerably in excess of the demand both now and in the foreseeable future." DuPont had manufactured hyperpure semiconductor silicon for the electronics industry since 1952 at its Brevard plant.

MINERAL FUELS

Mineral fuels consist of coal, natural gas and petroleum and products derived from these materials. During the period 1960-1967, North Carolina did not produce any mineral fuels, but there was interest and some activity in exploring for gas and petroleum.

Coal

The known coal deposits of North Carolina are found in the Deep River Coal Field which underlies parts of Chatham, Lee and Moore counties. Thi
coal field has been known and prospected at intervals for more than 100 years. In 1955, the Unite
States Geological Survey published Professiona
Paper 246, "Geology of the Deep River Coal Field
North Carolina," by John A. Reinemund which describes the geology and coal reserves of this fiel
in detail. Based on geologic information, coal outcrops, mine sections and records of 30 diamond-dril
holes, the report estimates the field to contain approximately 101,989,000 tons of coal of which 50,185,000 tons are recoverable under present economi
conditions. The coal is bituminous and contains 3
percent volatile matter, 59 percent fixed carbon, an
6 to 9 percent ash. Much of the coal is coking. Th
heat value of the coal is slightly in excess of 14,00
b.t.u.

The coal field which is elongated in a northeast
southwest direction is broken by a number of well
developed northeast-southwest trending faults
There are also a number of minor northwest trendin
cross faults that are not so well established. Thi
faulting has prevented successful coal mining i
the field.

In July 1959, the Division of Mineral Resource
attempted to locate these cross faults by a geophysical survey. It was thought that electro-resistivity equipment might locate these minor cros
faults. The results obtained between July 1, 195
and July 20, 1959 were unsatisfactory and the survey was discontinued.

No attempts were made to mine coal from thi
field during the period 1960-1967.

Oil and Gas

North Carolina is not a producer of oil or gas
However, between July 1, 1924, and June 30, 1960,
total of 35 exploratory wells were drilled for oil an
gas in the state. All of these wells were located i
the eastern half of the Coastal Plain which is th
only part of the state that contains geologic conditions which offer possibilities for the accumulatio
of oil and gas.

In 1960, Peter Henderson Oil Company of Ne
York City, drilled three exploratory wells in th
Hoffman Forest of Jones and Onslow counties, abou
10 miles north of Jacksonville, the county seat o
Onslow County. Well No. 1, located in Onslow Count
reached a depth of 1232 feet. Well No. 2, located i
Jones County reached a depth of 1239 feet. Wel
No. 3, located in Onslow County reached a depth o
1325 feet. None of these wells reached basemen
(crystalline rocks) or showed any signs of oil or gas

On October 28, 1954, J. E. FitzPatrick of For

Worth, Texas, was granted a lease to explore for oil, gas and sulphur beneath the bottoms of sounds, rivers and creeks in the Coastal Plain of North Carolina, north and east of a line from the courthouse in New Bern to the courthouse in Beaufort and east of the 77th meridian of longitude.

In the fall of 1958, with the approval of the Board of Conservation and Development and the Governor and Council of State, this lease was assigned to the Coastal Plains Oil Company, a North Carolina corporation.

In 1961, Coastal Plains Oil Company drilled 3 wells in Carteret County as follows: (1) the G. P. Yeatman No. 1 Well—4096 feet deep; (2) the Bay Land Corporation No. 1 Well—5609 feet deep and (3) the Huntley-Davis No. 1 Well—4965 feet deep. Basement was reached in the Bay Land Corporation No. 1 Well at a depth of 5570 feet and in the Huntley-Davis No. 1 Well at a depth of 4955 feet. No oil or gas was found in these three wells.

In 1963, Coastal Plains Oil Company drilled 5 wells in Beaufort County as follows: Rodman No. 1 Well—reached a depth of 2012 feet—basement at 1980 feet; (2) Zeno Ratcliff No. 1. Well—reached a depth of 1966—basement not reached; (3) Rodman No. 2 Well—reached a depth of 2113—basement not reached; (4) West Dismal No. 1 Well—reached a depth of 1938 feet—basement at 1930 feet; (5) H. M. Jackson No. 1 Well—reached a depth of 1526 feet—basement not reached. No oil or gas was encountered in these wells.

In December 1963, the lease on state-owned submerged lands held by Coastal Plains Oil Company was assigned to Socony Mobil Oil Company. Subsequently, in February 1964, Socony Mobil Oil Company began an extensive seismic exploration program in the eastern Albemarle Sound area in the vicinity of Manteo. The exploration program lasted until August 1964 and included some off-shore work. This was followed by a drilling program in July and August 1965, when three holes were drilled as follows: (1) Mobil No. 1 Well drilled in Albemarle Sound to a depth of 5255 feet—basement at 5165; (2) Mobil No. 2 Well drilled in Albemarle Sound to a depth of 8381 feet—basement at 8360 feet; (3) Mobil No. 3 Well drilled in Pamlico Sound to a depth of 7266 feet—basement at 7220 feet. No oil or gas was found in any of these holes.

Between September 25, 1965 and December 22, 1965, Edwin Foster Blair and Associates of New York City drilled five exploratory holes in North Carolina as follows: (1) Blair No. 1 Well drilled in Camden County to a depth of 3747 feet—basement at 2822 feet; (2) Blair No. 2 Well drilled in Currituck County to a depth of 4553 feet—basement at 4526 feet; (3) Blair No. 3 Well drilled in Dare County to a depth of 6291 feet—basement at 6268 feet; (4) Blair No. 4 Well drilled in Dare County to a depth of 5144 feet—basement at 5124 feet; (5) Blair No. 5, Well drilled in Hyde County to a depth of 5540 feet—basement at 5522(?) feet. No oil or gas was found in any of these holes.

In October 1965, North Carolina Oil and Gas Company, a North Carolina company, requested a lease to explore for oil and gas on state-owned submerged lands in Carteret, Onslow, Pender, New Hanover and Brunswick counties. This request was granted in April 1966.

In February 1966, North Carolina Oil and Gas Company began an extensive exploration program for oil and gas in the general area of Pender and Onslow counties in southeastern North Carolina. This program of exploration was continued through the years 1966 and 1967 during which time fifteen wells were drilled as follows: Chowan No. 1 Well drilled in Pender County to a depth of 1004 feet—basement at 990 feet; Batts No. 1 Well drilled in Pender County to a depth of 1493 feet—basement at 1480 feet; James No. 1 Well drilled in Onslow County to a depth of 1754 feet—basement at 1247 feet; International Paper No. 1 Well drilled in Onslow County to a depth of 1294 feet—basement at 1247 (?) feet; Batts No. 2 Well drilled in Pender County to a depth of 1462 feet—basement at 1456 feet; MacMillian No. 1 Well drilled in Pender County to a depth of 1431 feet—basement at 1410 feet; Lea No. 1 Well drilled in Pender County to a depth of 1255 feet—basement at 1250 feet; Sheppard No. 1 Well drilled in Onslow County to a depth of 1275 feet—basement at 1273 feet; Justice No. 1 Well drilled in Onslow County to a depth of 1680 feet—basement at 1667 feet; Fort Fisher No. 1 Well drilled in New Hanover County to a depth of 1558 feet—basement at 1545 feet; International Paper No. 2 Well drilled in Onslow County to a depth of 1403 feet—basement not reached; Baucom No. 1 Well drilled in Onslow County to a depth of 1418 feet—basement at 1412 feet; Evans No. 1 Well drilled in Onslow County to a depth of 1368 feet—basement at 1368 feet; Sullivan No. 1 Well drilled in Pender County to a depth of 1472 feet—basement not reached; Spicer No. 1 Well drilled in Onslow County to a depth of 1174 feet—basement not reached.

Shows of gas were reported in two of these wells, but not in sufficient volumes to be of economic importance and the wells were plugged and abandoned.

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